non | linear

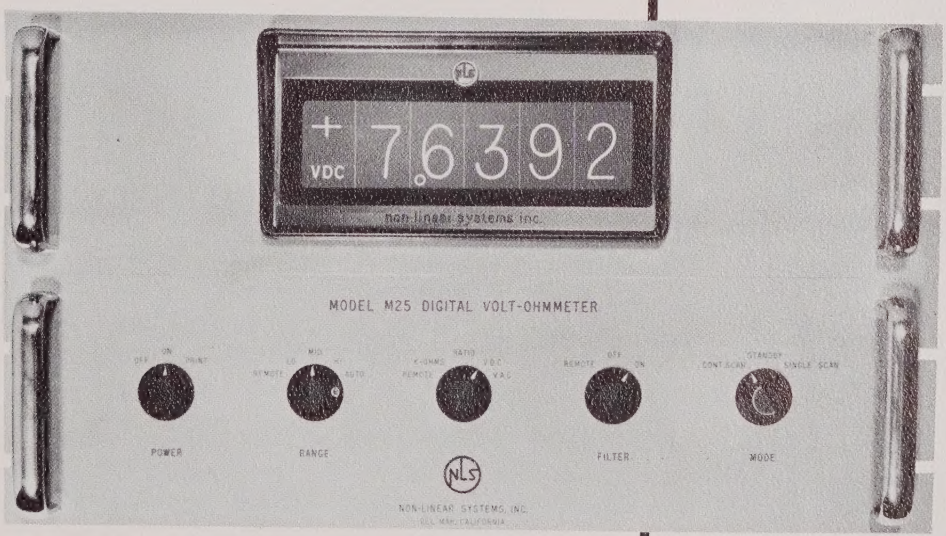
NLS

systems, inc.

DEL MAR, CALIFORNIA

Instruction Manual
Digital Volt-ohmmeter
Model M25

KΩ
DC
AC
RATIO



This manual is for instrument Serial No._____

non linear systems, inc.
DEL MAR, CALIFORNIA

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INTRODUCTION

NLS Series 20 measuring instruments are expressly designed to provide maximum accuracy, versatility, and reliability at a relatively high speed. The Model M25 is the premium instrument of the Series.

The M25 is a complete digital system which will measure DC volts to five digits, DC ratio to five digits, and resistance to five digits. All or any of the foregoing operations are controlled from the front panel; however, these operations may be performed remotely by plugging in cables which connect with remote actuators. With accessory devices, AC or low-level DC measurements may be made. In addition, all measurements displayed can be simultaneously fed to a printer for data-logging purposes.

The M25 makes full use of the latest transistor circuit techniques to enhance the instrument's reliability. The best qualities of the Series 20, established by over three years of use, are retained in this instrument. As with other instruments in the Series, switching operations are performed by extremely reliable mercury-wetted contact relays which have a life expectancy of 171 years' continuous operation at full instrument speed. The M25 provides a constant measuring speed of 1.1 seconds under all conditions of operation. Thus, its maximum measuring time is more than twice as fast as the most rapid meters employing stepping switches.

Over the years, instruments in the 20 Series have been found to require very little maintenance. This is due in large part to the use of mercury-wetted relays, as well as to the use of quality components throughout. Since over 99% of the components used in this instrument are on plug-in boards, almost any malfunction can be corrected quickly by the simple substitution of known good boards for others in the instrument. Thus the instrument need hardly ever be out of operation for more than a few minutes if spare plug-in boards are available. An unkeyed extension board may be used to raise any board in the instrument so as to make test points and components readily accessible. This test board is stored within the instrument, just behind the readout. Since no components are located below the base board, the instrument need not be inverted for servicing. The lamps used in the readout are of a type which resists vibration damage. In addition, lamp life is increased by a transistor-switched regulated power supply which limits surge current to a cold filament. Also contributing to long life and trouble-free operation, is the fact that the instrument does not produce much heat; it dissipates only 60 watts.

If more detailed operation and maintenance information is required, please contact the nearest Regional Sales and Service office listed on page 6, or contact the NLS main plant at Del Mar, California.

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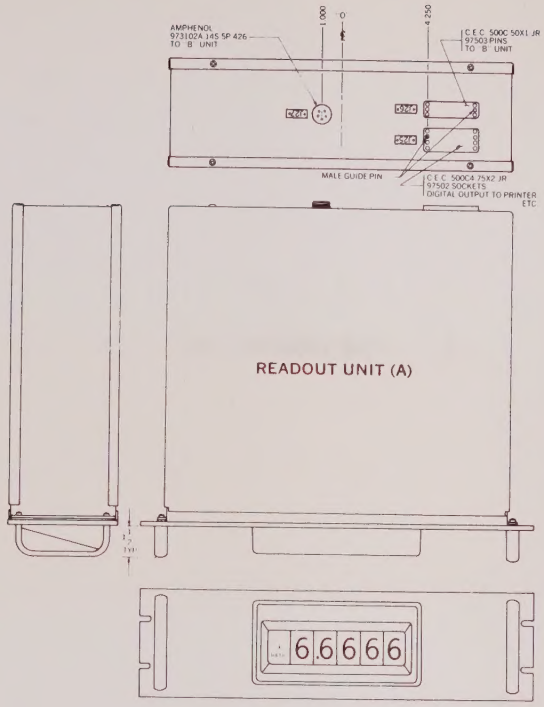
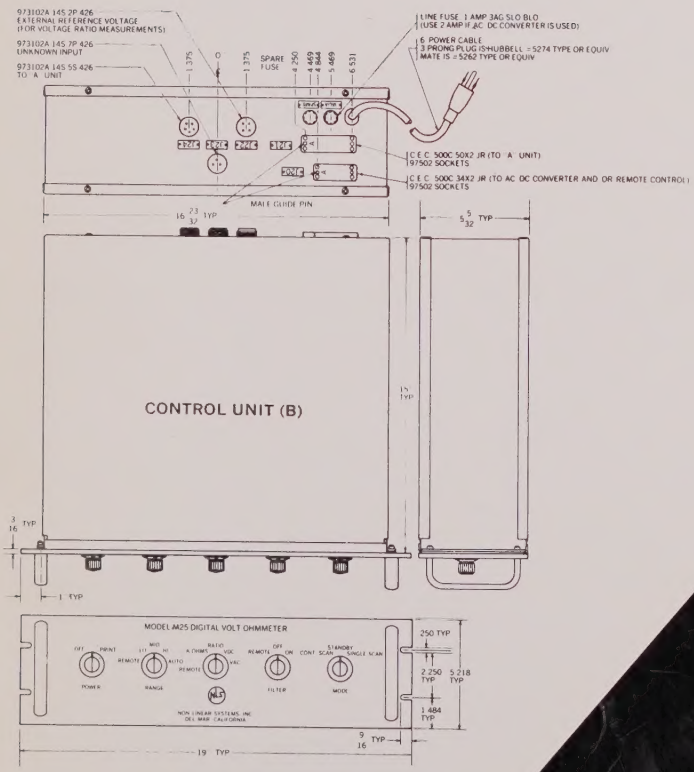
15004-078	Sheet 1	Cable: Reference
15004-079	Sheet 1	Cable: Power & Logic


AMPHENOL
9731024 145 SP 426
TO 'B' UNIT
1.000
0
4.250
C.E.C. 500C 50X1 JR
97503 PINS
TO 'B' UNIT
MALE GUIDE PIN
C.E.C. 500C4 75X2 JR
97502 SOCKETS
DIGITAL OUTPUT TO PRINTER
ETC
READOUT UNIT (A)
6.6666


9731024 145 2P 426
EXTERNAL REFERENCE VOLTAGE
(FOR VOLTAGE RATIO MEASUREMENTS)
9731024 145 7P 426
UNKNOWN INPUT
9731024 145 5S 426
TO 'A' UNIT
1.375
0
1.375
SPARE
FUSE
4.250
4.469
4.469
5.469
6.531
LINE FUSE .1 AMP 3AG SLO BLO
(USE 2 AMP IF AC DC CONVERTER IS USED)
6 POWER CABLE
3 PRONG PLUG (SHUBBELL = 5274 TYPE OR EQUIV
MATE IS = 5262 TYPE OR EQUIV
C.E.C. 500C 50X2 JR (TO 'A' UNIT)
97502 SOCKETS
C.E.C. 500C 34X2 JR (TO AC DC CONVERTER AND OR REMOTE CONTROL)
97502 SOCKETS
MALE GUIDE PIN
16 23/32 TYP
5 5/32 TYP
CONTROL UNIT (B)
17 1/2 TYP
5/16 TYP
1 TYP
MODEL 425 DIGITAL VOLT OHMMETER
POWER
RANGE
FILTER
MODE
NON LINEAR SYSTEMS, INC
DEL MAR, CALIFORNIA
250 TYP
2.250 TYP
5.218 TYP
1.484 TYP
9/16 TYP
19 TYP

SPECIFICATIONS

Section Two

Digits Displayed:
Five digits (decades) in the decimal system.

Ranges:
DC voltage: ±0.0001 to 999.99 in ranges of ±9.9999/99.999/999.99.

DC voltage ratio: ±.00001 :1 to ±99.999 :1 in ranges of ±.99999/9.9999/99.999.

Resistance: 0.1 ohms to 999.99 kilohms in ranges of 9.9999/99.999/999.99 kilohms.

For AC ranges of 9.999/99.99/999.9 use NLS 125E AC/DC Converter. For microvolt measurements, use NLS 141 Preamplifier.

For AC voltage ratio measurements, use 125E and 125ER Converters.

Accuracy:
±(0.01% of reading +1 digit).

Resolution: (Sensitivity)
±0.002% of full scale of range in use.

Input Impedance:
10 megohms on all voltage and ratio ranges, except 1000 megohms on ±.99999 ratio range. Input impedance for external reference voltage used for DC voltage ratio measurements is 200,000 ohms.

Reference Voltage: (For DC voltage ratio measurements)
Any DC voltage from ±10 to ±100 V. can be used without requiring any adjustments.

Input Filter:
60 db down @ 60 cps for DC voltage or voltage ratio input (not reference) signal. Filter may be switched locally or remotely.

Balancing Time:
1.1 seconds, constant, per measurement.

Polarity Indication:
Automatic.

Range Changing:
Automatic, manual or remotely programmed.

Programming:
All front-panel switch functions can be duplicated by external contact closures except for the functions of the POWER switch.

Construction:
Logic circuits are transistorized. Mercury-wetted contact relays are utilized for switching in the numerical digitizing circuits.

Primary Power:
115 volts ±10%, 60 cps, 60 watts.

Weight:
Shipping, 80 lbs.; net 65 lbs.

Warranty

The original purchaser of this instrument can request repair and adjustment service as needed. Usually no charge will be made during the first year except for such parts as lamps, choppers, tubes, fuses, etc. After one year, the District Office will occasionally charge for service. See page 6 for District Office locations.

NLS DISTRICT OFFICES

SOUTHWEST REGION

NLS
1015 Fremont Avenue
South Pasadena, California
213-682-3705

NORTHWEST REGION

NLS
415 Cambridge Street
Palo Alto, California
415-321-7323

NLS
208 Carlson Bldg.
Bellevue, Washington
206-454-9332

NLS
709 W. Littleton Blvd.
Littleton, Colorado
303-798-6762

NLS
2354 E. Blaine Avenue
Salt Lake City, Utah
801-466-6224

SOUTH CENTRAL REGION

NLS
208 Exchange Bank Bldg.
100 Exchange Park North
Dallas, Texas
214-351-5240

NLS
P.O. Box 35007
Houston, Texas
713-623-1845

NLS
3404 Pitt N.E.
Albuquerque, New Mexico
505-298-3546

NLS
4202 N. 27th Street
Phoenix, Arizona
602-274-7008

NLS
107 Williams Street
Huntsville, Alabama
205-534-1077

NORTH CENTRAL REGION

NLS
1915 N. Harlem Ave.
Chicago, Illinois
312-889-1277

NLS
3300 Dixie Drive
Dayton, Ohio
513-298-8638

NLS
4105 Northern Pike
Monroeville, Pa.
412-372-7858

SOUTHEAST REGION

NLS
1008 N. Randolph St.
Arlington, Virginia
703-524-4732

NLS
1500 King's Highway
Cherry Hill, New Jersey
609-428-1663

NLS
705 W. Colonial Drive
Orlando, Florida
423-8901

NLS
6300 Kenilworth Road
Riverdale, Maryland
301-864-8121

NLS
3224 Peachtree Rd., N.E.
Atlanta, Georgia
404-233-1375

NLS
387 Passaic Avenue
Caldwell, New Jersey
201-228-2525

NLS
50 Jericho Turnpike
Jericho, L.I., New York
516-333-7020

NLS
Pickard Building
E. Molloy Road
Syracuse, New York
315-454-9304

NLS
235 Bear Hill Road
Waltham, Mass.
617-899-1430

EXPORT

Frazar & Hansen Ltd.
150 California Street
San Francisco, Calif.
415-981-5262

CANADA

Aeromotive Engineering Products Ltd
887 Montee de Liesse
St. Laurent, Quebec, Canada
514-747-4781

HAWAII

Kentron-Hawaii
1232 Waimanu Street
Honolulu 14, Hawaii
512-781

MODE – CONTINUOUS SCAN: The instrument makes measurements repeatedly. However, if the power switch is at PRINT, the instrument will not scan again until the printer furnishes an "end of print" signal (Form C contact transfer)

STANDBY: Instrument is energized but holds last reading

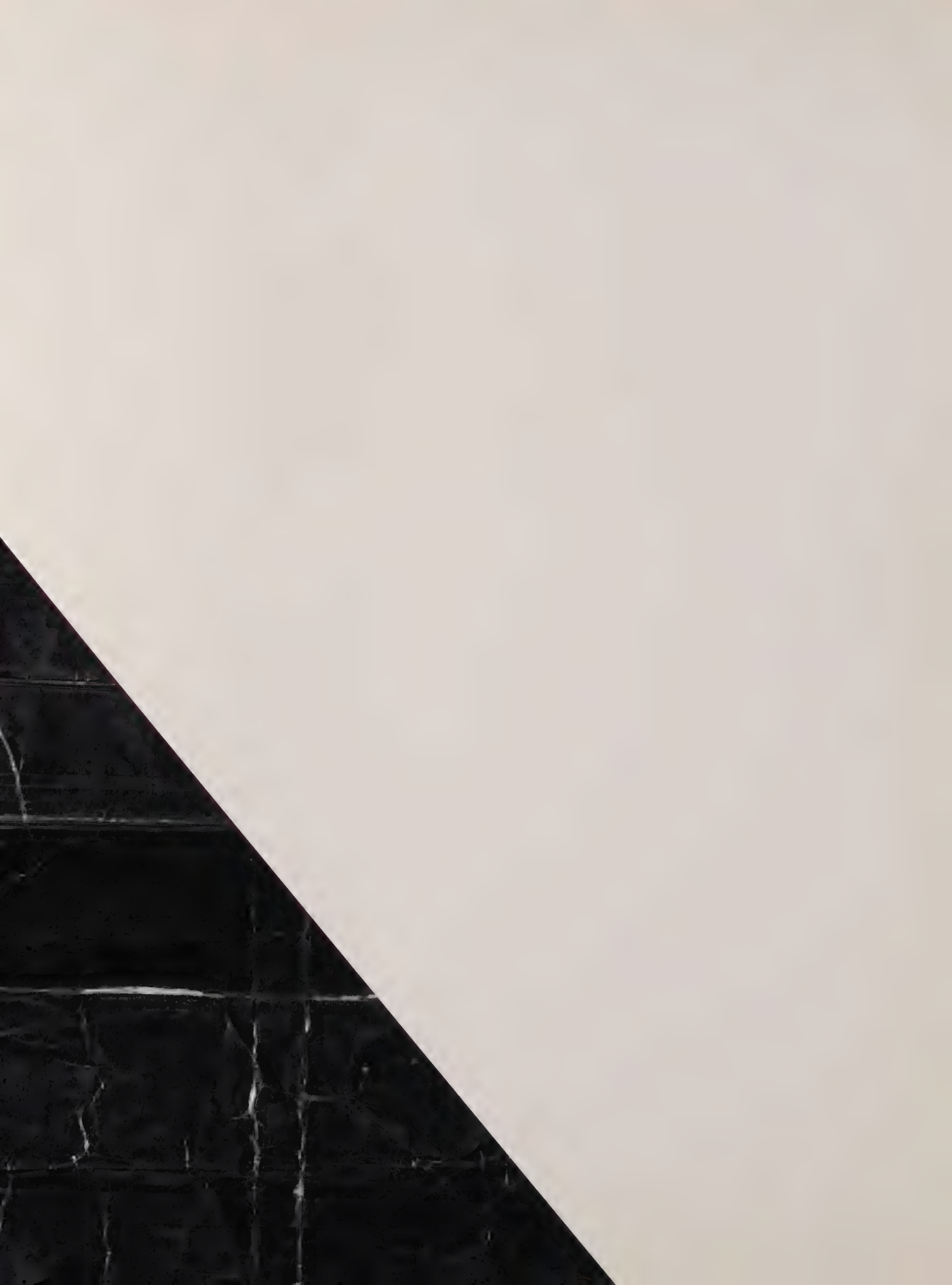
SINGLE SCAN: Turning the spring-loaded knob from STANDBY to SINGLE SCAN produces one reading, and the instrument holds that reading until this knob is turned to SINGLE SCAN again.

FILTER – Knob connects and disconnects input filter; to control by remote contact closures see Page 123.

FUNCTION – Turn to type of measurement desired: Kilohms, DC Ratio, Volts DC or Volts AC (with accessory AC/DC converter). For remote function selection, see Page 123. When using the NLS 125ER to convert an AC reference voltage to DC for making AC ratio measurements, set the M25 function switch on RATIO.

RANGE – Set to DC or AC range (with accessory AC/DC converter) desired or to AUTO for automatic selection and indication of range. LO covers ±9.9999 DC voltage, ±.99999 DC voltage ratio, and 9.9999K ohms. MID ranges are ±99.999 DC, ±9.9999 ratio, and 99.999K ohms. HI ranges are ±999.99 DC, ±99.999 ratio, and 999.99K ohms. Set to LO for low-level DC voltage measurements with NLS 141 Preamplifier. With knob at REMOTE, remote contact closures select DC or AC ranges.

POWER – At PRINT, print command is automatically issued at the end of each reading. At ON, print command is inhibited. At OFF, the instrument is completely de-energized,



INSTALLATION AND OPERATION

Section Three

I UNPACKING THE INSTRUMENT

The Model M25 Digital Voltmeter consists of two modules, each 5¼ inches high, designed to be installed in a standard 19-inch rack or cabinet. Since each module is completely enclosed, it may also be operated on the bench.

The instrument is shipped in separate expandable polystyrene-bead containers from which the two halves of the M25 may be lifted. Before connecting the instrument, make certain that there is no visible damage. If damage to the instrument is apparent, notify the closest district office listed on page 6. Check too, to see that all cables have been supplied with the instrument as listed in the following table:

PART NO.	PURPOSE	PLUG IDENTITY	LOCATION
15004-079	Power and Logic	50-pin Winchester	A unit to B unit
15004-078	Internal Reference	5-pin "AN" Connector	A unit to B unit
15004-077	External Reference	4-pin "AN" Connector	B unit to external reference volts
15004-075	Input	3-pin "AN" Connector	B unit to unknown input
15004-139	Printer Intelligence[1]	75-pin Winchester	A unit to print device or remote readout
15004-076	AC-DC Converter Control[2]	34-pin Winchester	B unit to AC-DC Converter

1. This cable is supplied only with a printer, adapter, or remote readout; otherwise a plug is supplied which can be wired to a recording device.

2. This cable is supplied only with an AC-DC Converter; otherwise, a plug is supplied which can be wired to provide remote function control, as shown in Figure 3-1.

II CABLE CONNECTIONS

Cables are connected as follows:

1. Connect all interconnecting input and control cables to the rear of the two modules of the instrument as shown at the left. See the table on page 8.

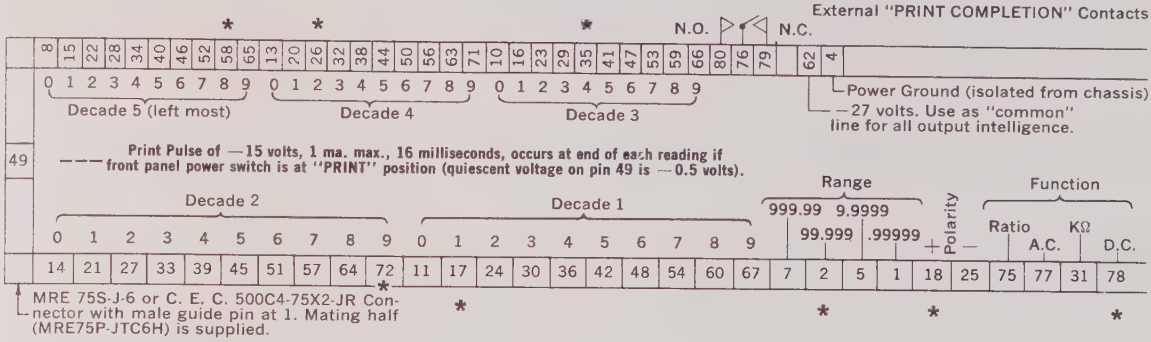
2. The input cable terminates in three connectors—a red clip, a black clip, and an uninsulated clip. The red clip (pin A) goes to the high-impedance side of the signal to be measured. The black clip (pin B) goes to the low-impedance or ground side of the signal to be measured. The uninsulated clip (pin C) goes to the shield or chassis of the device containing the signal to be measured. The meter will operate best if the black clip and uninsulated clip are connected together. However, this is not always possible, since the uninsulated clip is tied to the chassis of the instrument and to the line power ground; this can sometimes cause an imbalance among the signal, converter (if used), and DVM grounds. In any case, it is necessary that less than 100 millivolts of AC exist between the black and the uninsulated clips when any measurement is being made.

3. When an external reference source is to be used, the external reference cable is connected to the reference voltage as follows:
   Red clip (pin A) to +voltage.
   Black clip (pin C) to reference ground (reference common).
   Red-black clip (pin B) to −voltage.
   The reference voltage can be at any potential from ±10 VDC minimum to ±100 VDC maximum. Accuracy is lessened if these limits are exceeded.

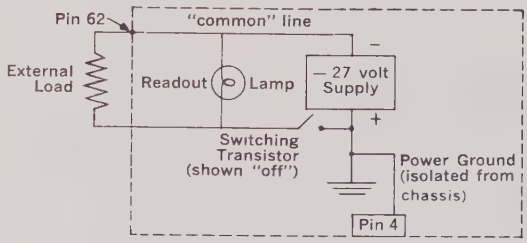
CAUTION

Do not connect the external reference, or have the POWER switch ON if the A or B units are not in proper operating position. Since the instrument is equipped with mercury-wetted relays which depend upon gravity to keep the mercury in its proper place, the instruments must not be tilted more than 30° from the horizontal. Failure to observe this precaution may cause damage to the external reference supply or the B-unit of the instrument, or both.

OUTPUT CONNECTIONS

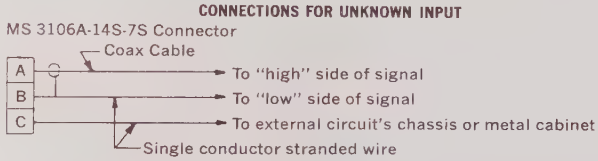

External "PRINT COMPLETION" Contacts
N.O.
N.C.
8 15 22 28 34 40 46 52 58 65 13 20 26 32 38 44 50 56 63 71 10 16 23 29 35 41 47 53 59 66 80 76 79 62 4
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9
Decade 5 (left most)
Decade 4
Decade 3
Power Ground (isolated from chassis)
—27 volts. Use as "common" line for all output intelligence.
49
Print Pulse of —15 volts, 1 ma. max., 16 milliseconds, occurs at end of each reading if front panel power switch is at "PRINT" position (quiescent voltage on pin 49 is —0.5 volts).
Decade 2
Decade 1
Range
999.99 9.9999
99.999 .99999
Polarity
Function
Ratio
KΩ
A.C.
D.C.
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9
14 21 27 33 39 45 51 57 64 72 11 17 24 30 36 42 48 54 60 67 7 2 5 1 18 25 75 77 31 78
MRE 75S-J-6 or C. E. C. 500C4-75X2-JR Connector with male guide pin at 1. Mating half (MRE75P-JTC6H) is supplied.

All information displayed on the readout is brought to a connector for operating external equipment such as data printers. With respect to Pin 62, +27 v. appears on pins corresponding to illuminated symbols in the readout ("ON" pins); +0.5 v. appears on the other pins. With +27 v. on the asterisked pins in the above drawing, the instrument's reading is +82.491 volts. Current available for external equipment is 5 ma. for each "ON" pin; snapping out the digital readout permits drawing up to 45 ma., non-inductive or diode protected. If external loads are connected using Pin 4, instead of Pin 62, as the common line: 1) —0.5 v. appears at "ON" pins and —27 v. appears on all other pins; 2) the readout lamp reduces the output voltage. Note: Do not draw more than 200 ma., total, from the output connector. If more current is required, use an NLS 180 Output Adapter which converts the output connector voltages into contact closures. Because an NLS 155 Data Printer and 180 Output Adapter each draw only 2.5 ma., they can be operated simultaneously from a Series 20 instrument by using a junction box.



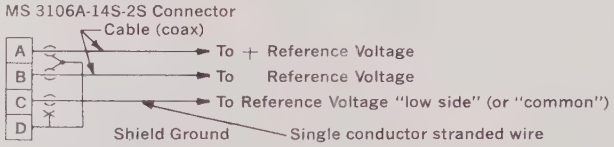
Typical digital output circuit for each decade.

CONNECTIONS FOR UNKNOWN INPUT

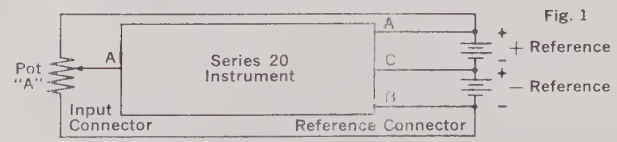


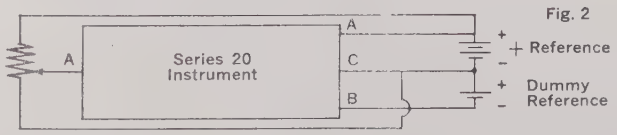
The coax cable can be RG122/U. Coax cable must be used for high speed, high accuracy measurements to minimize measurement inaccuracies caused by dielectric absorption and noise generated by the cable. Signal "low" side is isolated from the Series 20 instrument chassis ground by a 1 mfd. capacitor shunted by a 1 megohm resistor. This ground isolation minimizes errors caused by ground loops. The 1 megohm resistor can be removed in most applications.

EXTERNAL REFERENCE VOLTAGE CONNECTIONS
(for making voltage ratio measurements)

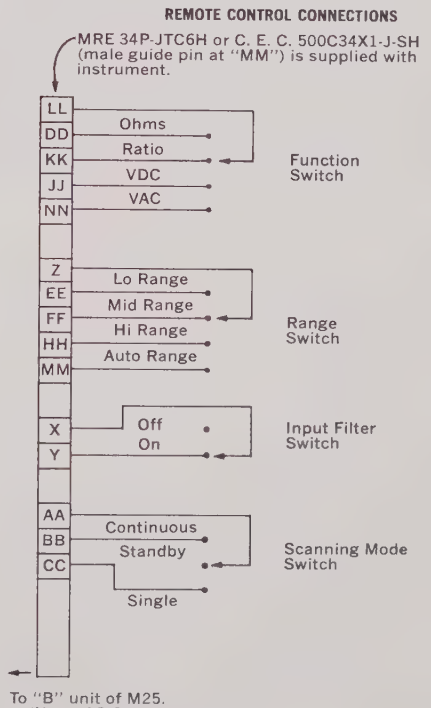


For measuring both + and — input signals, a + and — external reference voltage supply must be connected as in Fig. 1, where the voltage ratio from potentiometer "A" is being measured. For measuring the ratio of a single polarity input voltage, refer to Fig. 2. The dummy reference can be from 10 to 100 volts (a 12 v. battery is satisfactory), and is connected only to prevent the instrument from changing to — polarity with zero input, whereupon it would read —.99999 if the — reference voltage is zero. Load on external reference is 200,000 ohms. The + reference is loaded when input voltage is +; the — reference is loaded when input voltage is —





REMOTE CONTROL CONNECTIONS



Remote Function Selection: When the FUNCTION knob on the front panel of the M25 is turned to the REMOTE position, the remote function switch (shown above) can control selection of function.

Remote Mode Selection: Set the MODE knob of the front panel of the M25 to STANDBY. When the remote scan switch (above) is at SINGLE either continuously or for 10 milliseconds, minimum, the instrument makes one reading and stops. When the scan switch is kept at CONTINUOUS, the instrument makes readings repeatedly every 1.1 seconds.

Figure 3-1. Wiring Diagram.

III PRIMARY POWER

The Model M25 operates from a 105V to 125V, 60 cps power source. The instrument is supplied with a polarized power plug to utilize earth ground. It is important, especially so when an AC-to-DC converter is used, that the user's power receptacle be correctly wired with all potentials appearing at the plug of the instrument as shown in Figure 3-2. The M25 earth ground of the power cord is connected to the chassis ground of each module.

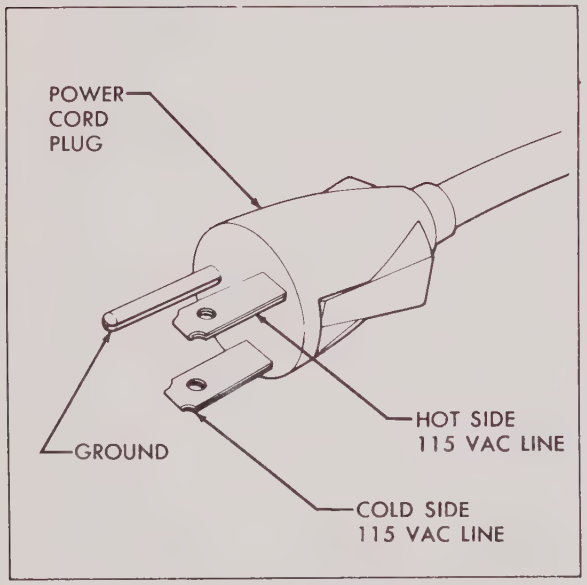


Figure 3-2. Power-plug Pin Coding.

IV FUSING

The Model M25 is provided with four active fuses. There are also five spare fuses located on the same board, and one on the rear apron.

1. The line fuse is located at the rear of the B unit. This fuse is a 3AG slo blo rated at 1 ampere to protect the instrument from high voltage, line overload, or shorts. When using an AC-DC converter, this fuse and its spare should be replaced with 2 ampere fuses. Five spare fuses are mounted inside the B unit on the rectifier assembly.
2. The power supply fuses are 2 ampere slo blo 3AG type, and are located inside the B unit on the rectifier assembly.

V FRONT-PANEL CONTROLS

The front panel, as shown facing page 6, is equipped with six controls:

CAUTION

Before manipulating any of the controls, be certain that excessive voltages are not applied to the input terminals of the instrument. Specifically, the maximums are:

1. 50 volts AC or DC with FUNCTION switch on OHMS,
2. 300 volts AC or DC with FUNCTION switch on VAC,
3. 300 volts AC or DC with FUNCTION switch on RATIO—unless the instrument is operating in the mid or high ranges,
4. 300 volts DC or AC with the FUNCTION switch on VDC—unless the instrument is in the mid or high ranges, and
5. 1000 VDC is not exceeded at any setting.
6. Also, the 115-volt AC, 60 cps line voltage must not be measured while the instrument is set at a DC function; with an AC-DC converter, the VAC function may be used if care is taken to correctly polarize the input leads.

• POWER SWITCH

The POWER switch has three positions:

OFF—At this position, the instrument is completely de-energized, although an earth ground connection is still made through the power cord.

ON—In this position, the instrument is able to perform all functions except printing.

PRINT—This position controls the print-command pulse and printer operation by providing a 16-millisecond pulse (−15 VDC at up to 1 milliampere load) which occurs at the end of the meter scan. This pulse appears at pin number 49 on the 75-pin connector at the rear of the A unit. This pulse is used to actuate the print recording device. Quiescent voltage is approximately −.5 VDC. Also on the PRINT position, a momentary single-pole contact closure is required in the printer. for the meter to operate in the CONTINUOUS mode. See description of MODE switch.

• FUNCTION

The FUNCTION switch has five positions:

1. REMOTE—This position transfers the function control to a remote station.
2. OHMS—This position is used to measure non-reactive resistance values.
3. RATIO—This position is used to measure DC voltage ratios.
4. VDC—This position is used to measure volts DC.
5. VAC—This position is used to measure volts AC when the instrument is used with an AC-DC converter.

• MODE

The MODE switch has three positions:

1. CONTINUOUS—This position allows the meter to scan repeatedly at a 1.1 second/reading rate. If the POWER switch is in the PRINT position, the meter will not scan a second time until "End of Print" information, in the form of a momentary 10 m.s. min. SPDT contact closure, is received from the printer.
2. STANDBY—With the switch in this position, the meter will complete an existing scan and stop until a new scan command is given by momentarily placing the MODE switch in the SINGLE SCAN or CONTINUOUS position.
3. SINGLE SCAN—This spring-loaded position allows the instrument to read a single time.

• RANGE SWITCH

The RANGE switch has five positions:

1. REMOTE—This position transfers range control to a remote station.
2. LOW—This position locks the meter in its lowest and most sensitive range.
3. MID—This position locks the meter in the middle range.
4. HIGH—This position locks the meter in its highest and least sensitive range.
5. AUTO—This position allows the meter automatically to select the most sensitive range consistent with the input.

• INPUT FILTER

This control has three positions:

REMOTE—This position transfers input filter control to a remote station.

OFF—This position bypasses the input filter, rendering it inactive.

ON—This position makes the input filter active. This filter consists of two cascaded L-C sections which provide 60 db of attenuation at 60 cps. When the M25 is used to measure resistances, the filter is automatically disconnected from the input circuit.

VI OPERATION

As a final check to establish that the instrument is properly connected and, at the same time, allow the operator to familiarize himself with the front-panel controls, several trial "runs" should be made. Procedures for manual, remote, and print recording operations are as follows:

• MANUAL OPERATION

1. Set the POWER switch to OFF, the RANGE switch to AUTO, and the FUNCTION switch to VDC, the FILTER switch to ON, and the MODE switch to CONT. SCAN.
2. Short the input leads together.
3. Connect the primary power cord to a 115 VAC 60 cps polarized outlet.
4. Set the POWER switch to ON. The readout should illuminate, and the instrument start scanning.
5. After approximately one minute of warm-up time, the instrument will display ±0.0000.
6. Allow fifteen more minutes of warm-up time to make precision readings.
7. Set the MODE switch to STANDBY and the FUNCTION switch to the particular type of reading to be taken. Open up the short at the ends of the input leads, and connect them to the unknown input being measured. The reading can now be made once by momentarily setting the MODE switch to SINGLE SCAN, or repeatedly by setting it to CONT. SCAN.

• REMOTE CONTROL OPERATION

1. Set the front-panel FUNCTION switch to the REMOTE position. If the 34-pin connector at the rear of the B unit is wired as shown in Figure 3-1, the function control of the instrument will be transferred to the remote function switch. Any function desired can be selected by operating the remote function switch.
2. Set the MODE switch to the STANDBY setting. Any setting of the MODE switch can now be remotely duplicated.
   a. Single-scan operation can be remotely actuated by a momentary closure (10 m.s. min.) of contact A as shown in Figure 3-1. Contact A should be opened for at least 10 ms. before reclosing.

b. Continuous scan operation can be obtained by a continuous closure of contact B as shown in Figure 3-1.

3. Set the front panel RANGE switch to the REMOTE position. If the 34-pin connector at the rear of the B unit is wired as shown in Figure 3-1, range control is transferred to the remote range switch. Any range can be selected by operating the remote range switch.
4. Set the front-panel FILTER switch to the REMOTE position. If the 34-pin connector at the rear of the B unit is wired as shown in Figure 3-1, the input filter control function is transferred to the remote filter switch. The input filter can then be turned on or off by the remote filter switch.

• PRINT RECORDING OPERATION

All information displayed in the readout is wired to the 75-pin connector located at the rear of the A unit. This information appears as a −0.5 VDC on the pin representing the window of the readout being lit. All windows not illuminated have a quiescent voltage of −27 VDC on their pins.

External connections to the 75-pin connecter should be made with the −27 VDC line used as a common. The unit is then energized when the lamp is lit in the readout and the external load is on the readout buffer. Available current for external devices is 5 ma. If the readout is removed, 45 ma. (non-reactive) can be obtained. If it is desired to connect to ground as a common, the load will be in series with the readout lamp and the current will be limited to 20 ma. However, because there are approximately 50 lamps not lit, and, therefore, a possible 50 energized loads with common ground, the load would be too great. Maximum total current from the plug should be limited to 200 ma.

Printing heads which plug directly into the 75-pin connector are available from NLS. Also, intelligence available for a printer can be used to drive an electronic serial converter for typewriters and other recording devices; if the current required to operate such devices is higher than the limits given in the preceding paragraph, parallel or serial adapters using relays should be used to convert the outputs from voltage representation to contact closures. The printing device may then be connected to the adapter. If the recorder has a common ground with the signal being measured by the Model M25, a relay adapter must be used to eliminate ground loops. It is suggested that a trial run may be made with the printing system as follows:

1. Connect the entire print-recording system to the digital voltmeter. For a continuous print mode of operation, the printer used must have a momentary SPDT contact closure actuated for at least 10 milliseconds when the printing is completed. A printer mechanism supplied by NLS is so equipped.
2. After the instrument has been allowed to warm up, set the MODE switch to STANDBY and the POWER switch to PRINT, in that order.
3. All front panel and remote control operations remain the same except, in some cases, for the CONT. SCAN mode. It may be necessary to actuate the SINGLE SCAN mode *one time* before setting the switch to CONT. SCAN. This single operation allows a capacitor in the B unit to charge, insuring operation of the CONT. mode. Because the meter now "waits" for the printer, the scanning period will change. Therefore, depending upon the speed of the printer being used, the number of readings being taken per second will drop when the operator switches to the PRINT position of the POWER switch.

The connections made between the printer and the digital voltmeter can be best understood by consulting Figure 3-3 which synthesizes the essential scan information from several schematic drawings. If an operating difficulty occurs, this drawing will be a useful adjunct to any study of the print recording operation. Note that the pulse lines are shown with the MODE switch in CONTINUOUS scan and the POWER switch set at PRINT.

VII REMOTE READOUT

The 75-pin connector at the rear of the A unit can also be used to connect a remote readout. The Model M25 readout circuits however, are not intended to accommodate two readouts. Therefore, the local readout must be removed before the remote readout is connected.

If the foregoing instructions have been followed, the instrument will be ready for use in any of its several modes, remotely or locally.

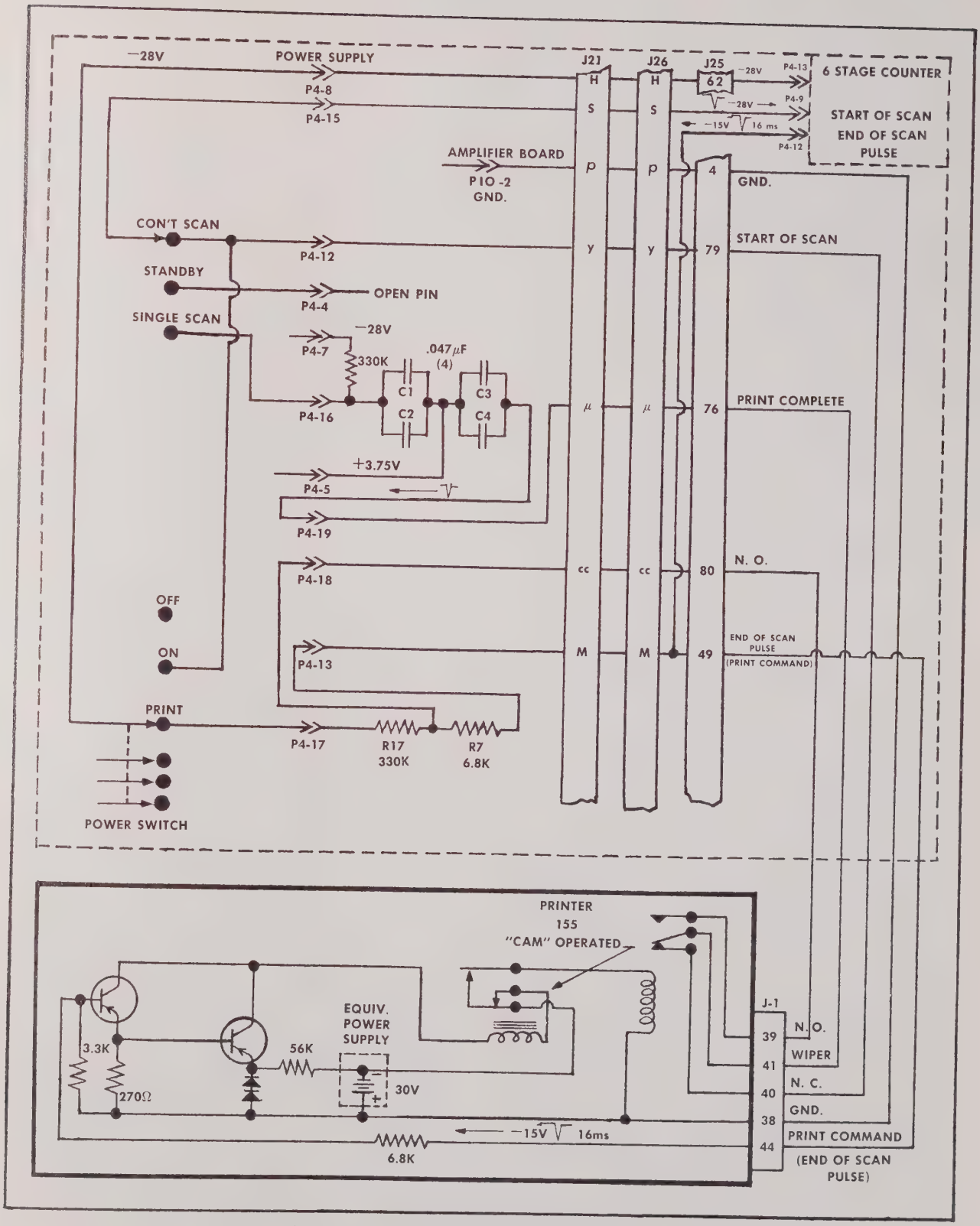
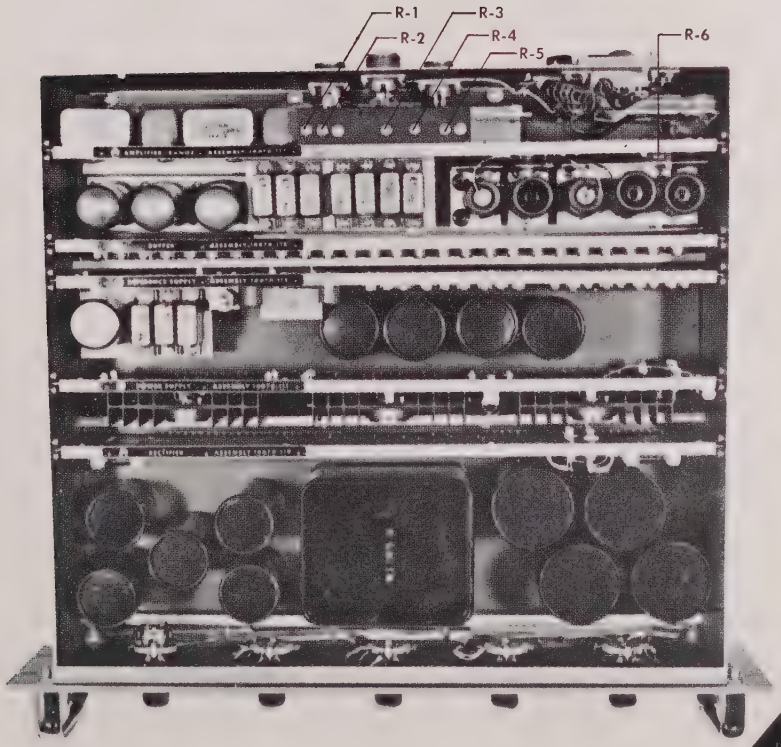


Figure 3-3. Printer-Digital Voltmeter Pulse Circuits.


R-1
R-2
R-3
R-4
R-5
R-6

CHECK-OUT AND CALIBRATION

Section Four

This section gives information on how to check the accuracy of the M25, and to calibrate it when needed. Calibration ordinarily will not require that all of the following steps be performed. Instructions in Part I, −28 Volt Supply Checkout, and Part II, Amplifier Checkout, can be bypassed when performing a "brush up" calibration. In order to perform all of the required calibration adjustments on the M25, the following equipment is needed:

1. *EMF standard, such as NLS Model 3006.* This EMF standard contains nine unsaturated cadmium standard cells connected in series, and provided with Superior Electric Five-Way binding posts which are connected to each series junction to make available the voltage from each cell. The available voltages range from approximately 1.019 to 9.172. The Model 3006 is supplied with two calibration tables which indicate voltage values carried to six decimal places and accurate to ±0.01%. One table gives the open-circuit EMF; the other table gives the output voltage values for a 10-megohm load, a typical load requirement when testing digital voltmeters. The table for a 10-megohm load is valid only at the temperature at which calibrated. In addition, the tables give the cumulative voltage of the cells such as 1.01924, 2.03843, 3.05764 . . . 9.17724. These cells have been calibrated at the NLS Standards Laboratory with an NBS certified primary voltage reference consisting of saturated Eppley Standard Cells housed in a Julie Research Laboratories oven.
2. *Ratio Box NLS Model 3020.* This box provides accurate 10:1 and 100:1 attenuation, and convenient switching facilities for fast, accurate calibration of digital voltmeter range-changing circuits. This ratio box is connected with Superior Electric Five-Way binding posts for convenient connection to the digital voltmeter along with an MS3102A-14S-2P Amphenol connector for connecting an external power supply. The 10:1 and 100:1 ratios are established at the NLS Standards Laboratory with strings of Julie resistors, each accurate to ±0.0015%. Using the techniques described in Julie Research Laboratory Notes, twenty 100K Julie resistors are used to create a reference voltage divider more accurate than ±0.0015%.
3. Any VOM with an internal resistance of 20,000 ohms per volt—a Simpson or a Triplett Meter having 3% accuracy is satisfactory.
4. An oscilloscope having a sensitivity of 200μv.
5. Test leads for both the volt-ohmmeter and oscilloscope which terminate in miniature alligator clips, in order to provide access to difficult-to-reach points. The Tektronix test probe is well suited to this use.
6. Three ohms standards, each having ±.01% accuracy. The ohmic values required are approximately 9K, 90K, and 900K. These resistors must be carefully shielded against stray pick-up or they can couple noise into the digital voltmeter and cause an erroneous standardization setting.

I −28 Volt Supply Check-out — consult schematic 10070-111.

Before making any check, insert a line voltage regulator in series with the power input of the M25, and vary the line voltage from 105 to 125 VAC while measuring a stable voltage. If the reading changes more than .03%, the following checks should be made with a VOM to measure voltage and an oscilloscope to measure the ripple content.

All voltages reference to P4-2 which is common.

PIN	VOM READING, VOLTS	MAX. RIPPLE
P4-7	−28	3 MV
P4-8	−28	6 MV
P4-1	−8.25	50 MV
P4-3	+1.5	10 MV
P4-4	+2.25	40 MV
P4-5	+3.75	40 MV
P4-6	+15.75	40 MV
P3-3	−24	1 MV
P3-1	−24	1 MV

II Amplifier Checkout — consult schematic 10070-117.

Short the input leads and adjust R6 so that the amplifier output level is approximately −1.7V as seen on a DC-coupled oscilloscope connected from P10-2 (ground) to P10-8 (amplifier output). See Figure 4-1. This control has an effect on the plus-to-minus offset, a condition in which a measurement made in one polarity does not numerically correspond to the same measurement made in the opposite polarity. Use a *low* impedance source such as a battery when checking plus-to-minus offset to guard against offset being caused by hum modulation of the signal. To see the amplifier output wave form at any reading other than zero, connect a clip-lead from the cathode side of CR17, the 5th diode from the upper left side of the 6-stage counter board (10070-013) to P4-5. CR17 is identified by the presence of a small triangle etched on the printed circuit board.

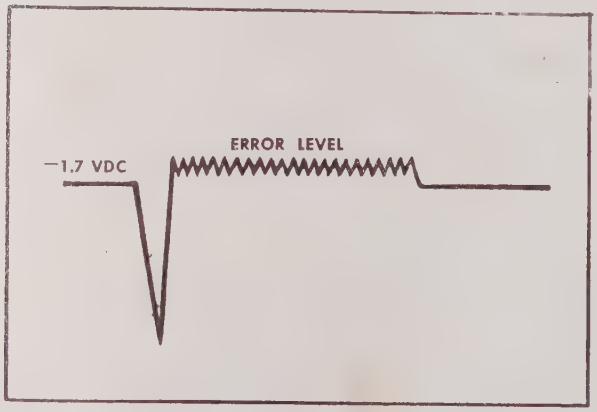


Figure 4-1. Amplifier Output Waveform.

III Reference Check-out — consult schematic 10070-113.

A. With the digital voltmeter displaying a minus polarity sign (any voltage) locked in STANDBY, adjust potentiometer R1 for +12 volts as read on a VOM connected from P6-2 to the collector of Q23, the gold transistor located on a heat sink directly beneath R1 and R2 potentiometers.

B. Connect a 20 mfd capacitor from the collector of Q23 to P5-16. Adjust R2 for minimum ripple; ripple should not exceed 200μv.

C. Connect the EMF standard cell bank to the input of the digital voltmeter and read the standard cell output on the digital voltmeter. If the reading is not accurate, adjust potentiometer R3 on the reference supply. If the mechanical limit of travel of R3 has been reached before adjustment can be achieved, it will be necessary to attach jumpers to (or remove jumpers from) certain resistors which are connected in series to one end of potentiometer R3. The resistors which may need to be shorted out are shown on the schematic as R7, R4, R10, R11, R12, R13, and R14.

IV Ranging Adjustment

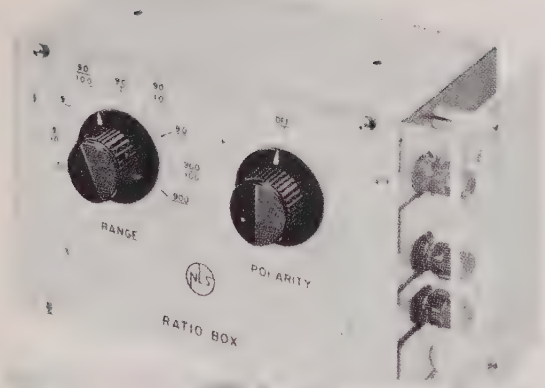
A. Connect the input leads of the voltage divider box and observe 90/10 volts. Switch to 90/1 volts, and adjust R2 in the amplifier to agree with the first reading except for decimal-point shift.

B. Connect the input leads to the divider box and observe 900/100 volts. Switch to 900/1 volts, and adjust R1 to agree with first reading except for decimal point shift.

V Ohms Calibration — consult schematic 10070-113.

1. Connect oscilloscope to amplifier output at P6-10.
2. Short the input leads.
3. Adjust R45 in the A Unit until error signal is about .5 volt above −1.7 volt level when the readout reads 0.0000. See Figure 4-1. Lock the potentiometer nut when the adjustment is complete.
4. Connect the input leads of digital voltmeter to an ohms standard accurate to ±.01%. The values required are shown in Steps 5, 6, and 7 below.
5. Apply approximately 9.0000K ohms, and adjust R5 (on amplifier range board) until readout agrees with standard.
6. Apply approximately 90.000K ohms, and adjust R4 (on amplifier range board) until readout agrees with standard.
7. Apply approximately 900.00K ohms, and adjust R3 (on amplifier range board) until readout agrees with standard.

Step 7 completes the check-out and calibration procedure.



MAINTENANCE

INNOVATION

Since the M25 is a complex instrument with hundreds of solid state components, it is difficult to locate readily any single defective item. If additional boards are available from a second similar instrument, or better yet, from a stock of spare boards, down time can be kept at a minimum. When spare boards are available, it is possible to rapidly isolate the defective board, in much the same manner as locating a defective Christmas tree bulb strung in series with other bulbs.

However, since spare boards are not always available, a series of block diagrams in this section will help the user to isolate defective circuit areas. To aid in troubleshooting, an extension board is stored directly behind the readout. Unlike many electronic instruments, the M25 does not have a particular function located only on a certain board. Thus, the reference supply is at one end of one board, and other circuits are at the opposite end. Figures 5-1 through 5-5, show the relationship of one circuit to another, both physically and electrically. The numerical list on each drawing establishes the physical location of specific circuit areas. Thus it is possible to trace separately the signal path for digits in the VDC and RATIO modes, as well as for the K-OHMS mode. Polarity and ranging functions are also shown. For example, if operation during the VDC mode is to be traced, Figure 5-1 shows that the signal input goes directly to the attenuator located on Board 1, the amplifier board, and so on.

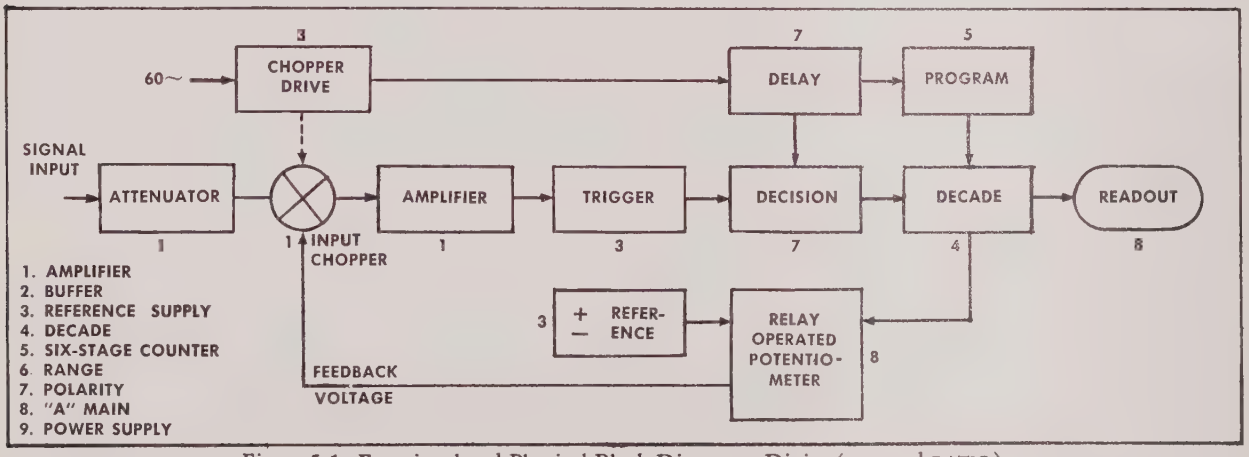


Figure 5-1. Functional and Physical Block Diagram: Digits (VDC and RATIO).

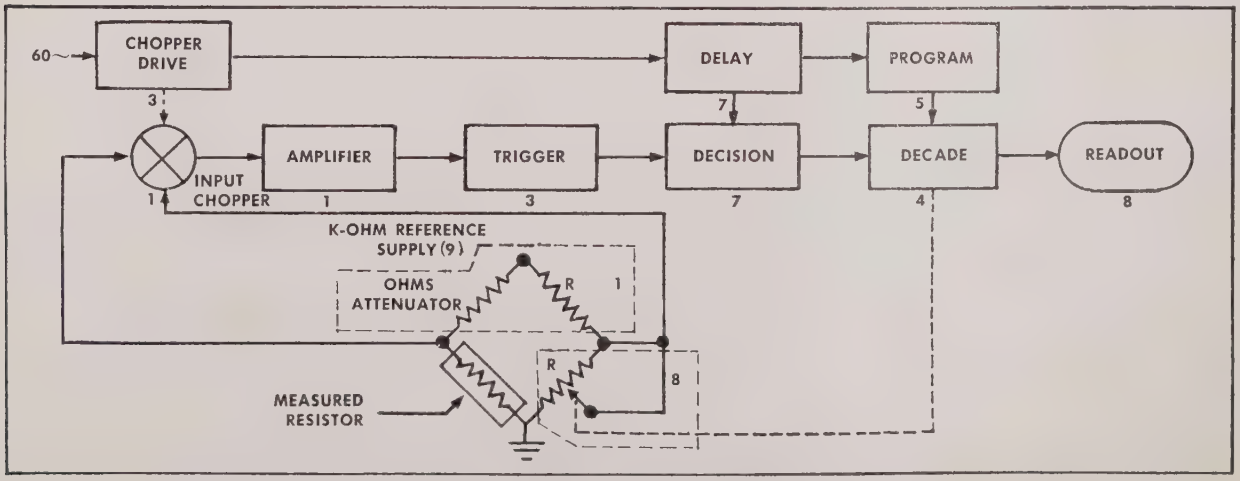


Figure 5-2. Functional and Physical Block Diagram: Digits (K-OHMS).

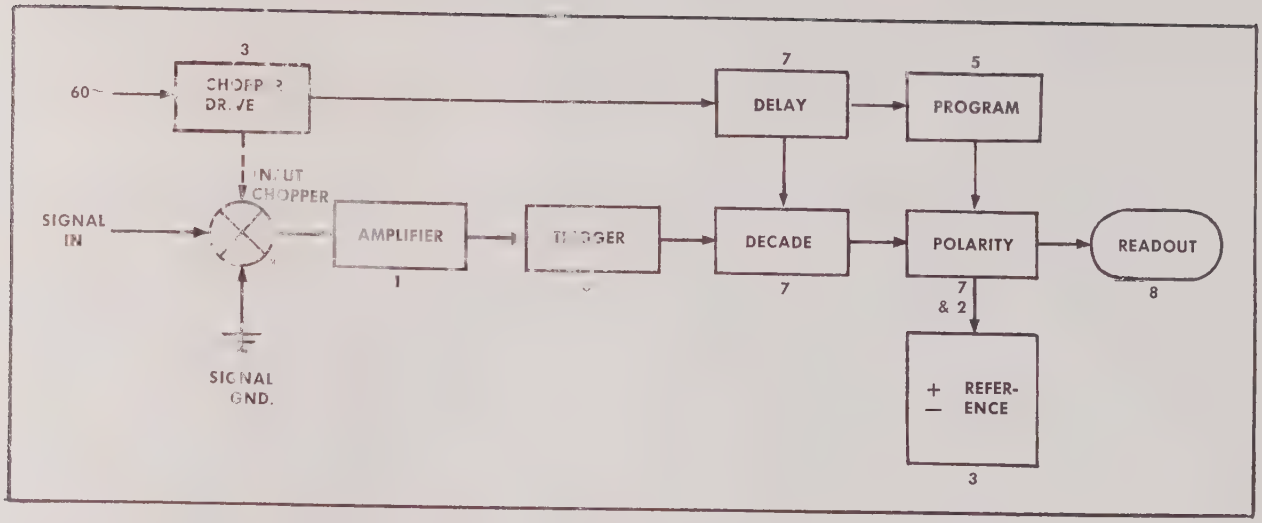


Figure 5-3. Functional and Physical Block Diagram: Polarity (VDC and RATIO).

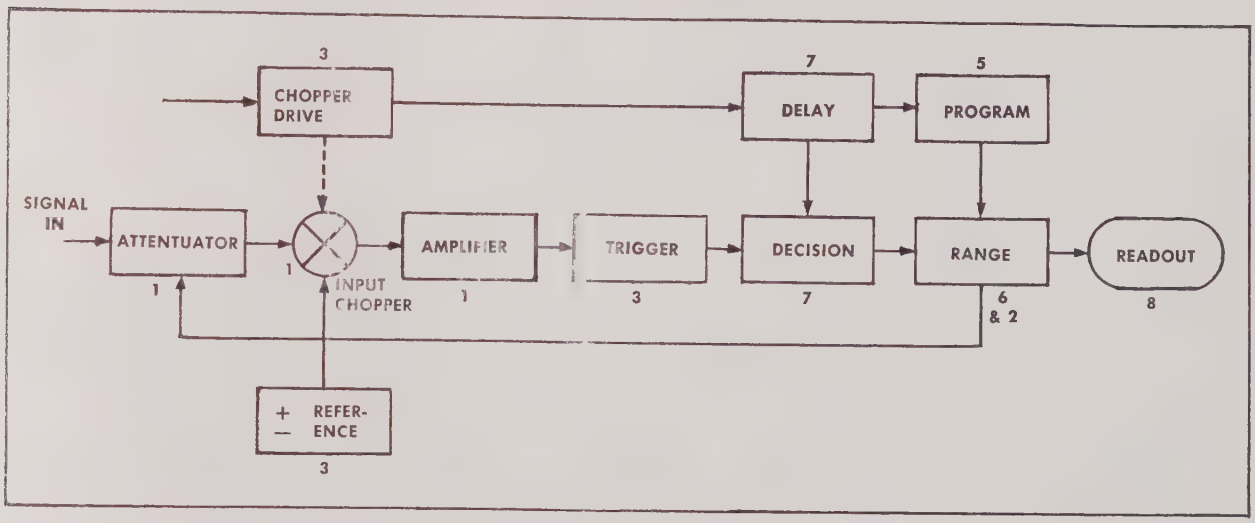


Figure 5-4. Functional and Physical Block Diagram: Ranging (VDC and RATIO).

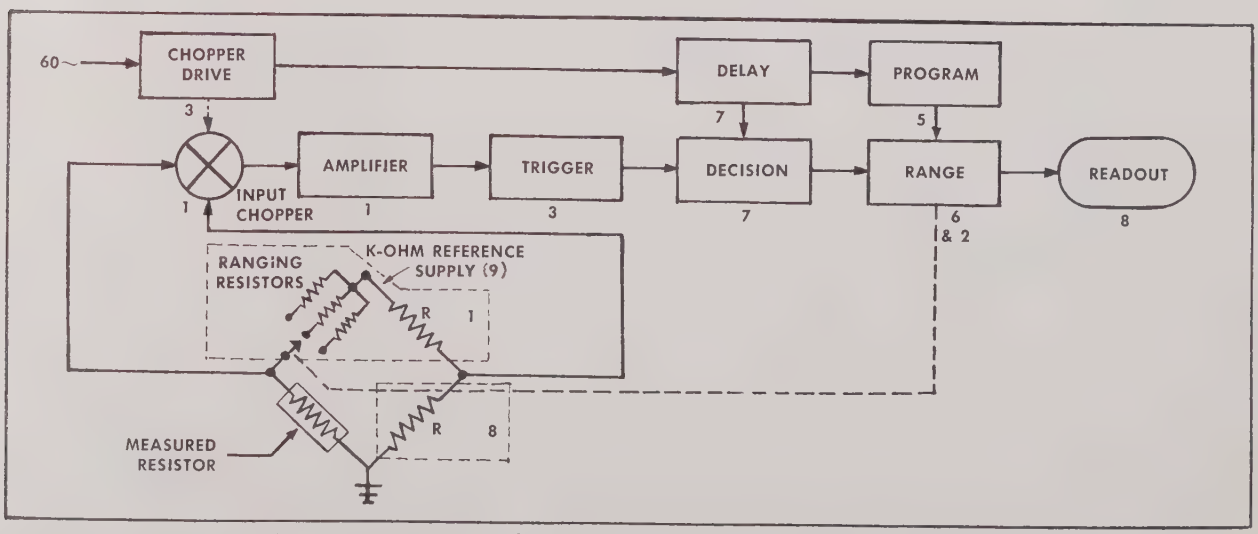


Figure 5-5. Functional and Physical Block Diagram: Ranging (K-OHMS).

GLOSSARY

The following glossary describes the cause-effect relation among the several blocks shown in Figures 5-1 through 5-9. Each glossary entry is number coded to agree with the physical location reference shown in the block drawings. Also, the same coding is used in all photographs of boards.

CHOPPER (1)

The chopper is a SPDT vibrator element which operates at power-line frequency. The center arm, which is connected to the amplifier, swings from the feedback voltage to the unknown input. Thus the chopper provides the amplifier with an input consisting of successive "glimpses" of both voltages so that the amplifier can "see" if differences exist.

AMPLIFIER (1)

In a sense, the term "amplifier" is a misnomer, since this circuit does not, in the ordinary sense, amplify an input signal. Instead, it presents one of three outputs: one output is a pulse when the unknown input is greater than the known feedback line voltage derived from the reference source; a second pulse output is generated when the unknown input is less than the feedback voltage; the absence of either of the two outputs from the amplifier indicates that the two voltages are equal, within specifications of the instrument. These pulses command the Wolff-Poggendorf voltage divider to raise or lower the known voltage in calibrated steps so that the known voltage is made to equal or "balance" the unknown voltage. See VOLTAGE DIVIDER.

TRIGGER (3)

The trigger consists of buffer transistors, buffer inverter transistors, and associated circuitry. The trigger systems convert the amplifier output as needed to operate the logic circuits.

DECISION BUFFER (7)

The decision buffer converts the information pulses derived from the decision matrix as needed to operate the range, polarity, and compute circuits.

DECISION MATRIX (7)

Decision matrix circuitry is located on the polarity decision board. This board has several functions: it receives timing, polarity, range, and trigger information; it converts this information into logical pulses which are fed to the decision buffer.

DECADE BOARDS (4)

When the amplifier "sees" that the difference between reference voltage and the input voltage are greater than one digit, it issues a compute command—via the trigger circuits—to the decade boards. These boards are so connected to the voltage divider that they "know" which resistors are switched in or out to achieve a balance. With this information, the decade boards offer a 2-4-2*-1 binary output which is changed into decimal system numbers on the decoding matrix. After decoding, the information returns to the decade board switching transistors to turn on the appropriate decimal readout lamps.

VOLTAGE DIVIDER (8)

A Wolff-Poggendorf voltage divider is used to raise or lower the feedback voltage in calibrated steps. Essentially, it consists of a group of high-speed mercury-wetted relays and precision resistors. The relays switch various resistors in and out of the circuit. Thus the known reference voltage is divided by this circuit. If the amplifier detects a difference between the unknown input voltage and the known output of the divider, the amplifier (and associated logical circuits) causes the relays in the divider to adjust the voltage divider output until it is within ±.01% of reading the value of the unknown input voltage, plus 1 digit.

INPUT ATTENUATOR (1)

The input attenuator is used to divide the input voltage by 100, 10, or 1, depending upon which range brings the input within the range of voltage available from Wolff-Poggendorf voltage divider. The process of selecting the correct range is done automatically by means of relays which respond to logical pulses derived from the decision buffer. To avoid damage to components from high-voltage inputs, the unknown input goes first to the 100/1 division. Thus, an input of 1,000 volts would be reduced to 10 volts before reaching the chopper contacts.

READOUT (8)

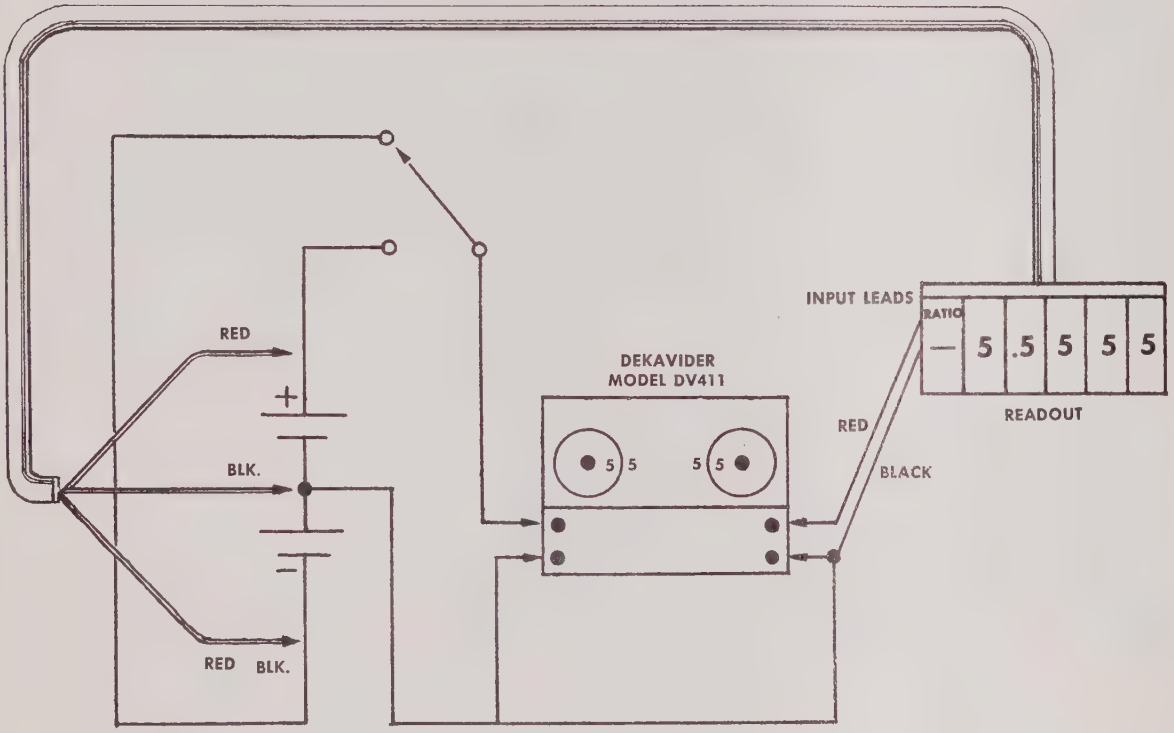
The readout displays in decimal form the volts, ratio, or ohms value shown at the input. At the same time, output voltages are present at a rear connector for operation of data recorders such as printers or punches. See Section 3, Installation & Operation.

PROGRAMMER AND DELAY (7, 5)

The programmer and delay circuits are used to provide the necessary timing information. Depending upon the mode of operation selected, the output of these circuits may be fed to the decision matrix, the decade boards, the polarity circuitry, or the range boards. See Figures 5-1 through 5-5.

TROUBLESHOOTING

SYMPTOM	PROBABLE CAUSE; CHECK POINTS; TROUBLE ZONES
A. Readout does not illuminate.	A. Check F-1 (power fuse). Inspect 28-volt supply. Readout common connection may not be touching brass pin on base of readout.
B. Readout lamps abnormally dim.	B. Defective 28-volt supply or extremely low AC line voltage.
C. Readout lamps excessively bright.	C. Defective regulating component in 28-volt supply.
D. Two or more numbers in same decade window light simultaneously.	D. Short between adjacent readout springs (gently bend back into shape with needlenose pliers). Bad diode in BCD-to-decimal matrix on associated decade board (least significant decade board is nearest the front of the M25). Exchange suspected decade board with adjacent board to see if "double number" condition shifts to different window.
E. Decimal point in wrong position.	E. Relay K5, K7, K8, K9 or K10 on amplifier board defective; broken wire to this relay. Defective component on range board. Range switch in wrong position—try AUTO position.
F. All lamps in readout light at same time.	F. Defective bias supply. Check power diodes on lower right of power supply board. Also check fuse F3 on rectifier board.
G. Readout reads all nines on just one range (DVM unable to range).	G. Check range board and amplifier relays.
H. Readout reads all nines in all ranges, both polarities.	H. If RATIO function works normally, then the zener reference supply or associated wiring is defective. If readout reads all nines on RATIO also, then the reference voltage path is open. Check polarity relay on reference board; check wiring through amplifier up to input chopper, K11.
I. Readings are not steady, will not settle to one number but continue to go above and below a set figure.	I. Turn FILTER switch ON. If reading has steadied, AC is probably getting into the input leads. If filter has no effect, check amplifier output wave form (see Calibration Section). If wave form is erratic, chopper is probably defective. Run instrument on RATIO, and if readings become steady, zener reference circuits are probably defective.
J. Instrument erratic on ohms function.	J. Check mercury relays in B-unit by substitution with known good relays.
K. Instrument fails to compute, or is erratic in all modes of operation.	K. Check K3 in B-unit. Check amplifier output waveform for defective chopper, etc. See Calibration Section for sample of correct wave form.
L. Instrument not linear in operation; calibration varies at different voltages.	L. Possible sticky relays in bridge (A-unit), or resistor in bridge out of tolerance. To check both cases, operate the instrument in the RATIO mode and connect as shown in Figure 5-6.



SET THE DEKAVIDER TO READ:

00000
+11111
+22222
+33333
+44444
+55555
+66666
+77777
+88888
+99999

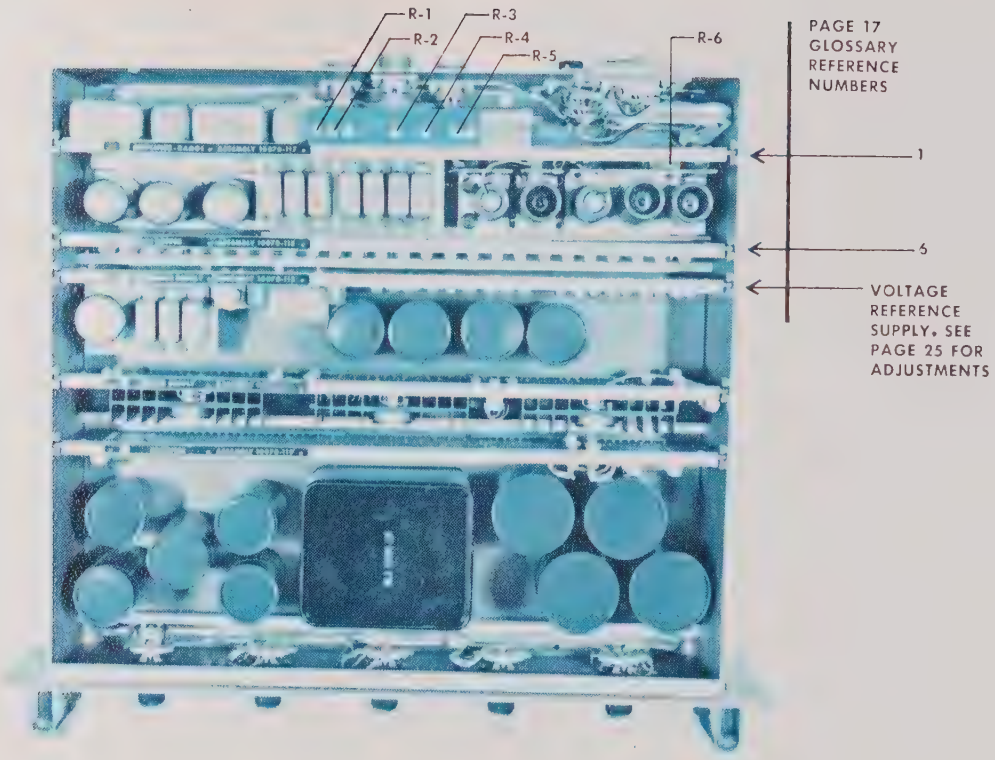
AT THIS POINT, REVERSE POLARITY AND PROCEED DOWNWARD FROM —99999 THROUGH 00000.

—99999
—88888
—77777
—66666
—55555
—44444
—33333
—22222
—11111
00000

NOTE:

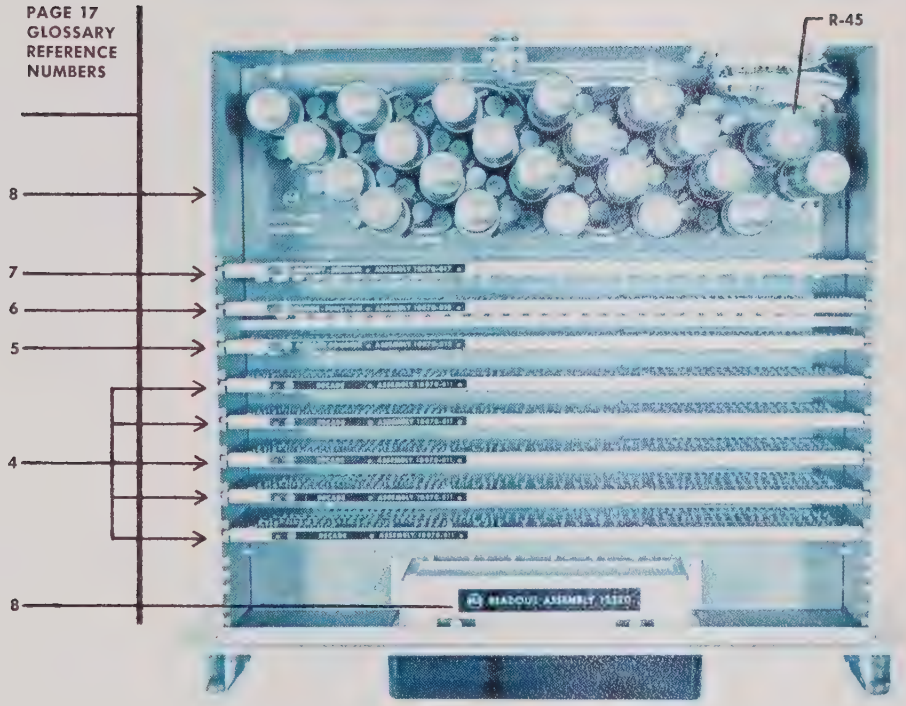
AT NO TIME DURING THE ENTIRE LINEARITY CHECK SHOULD THE M25 READINGS DEVIATE FROM THE DEKAVIDER SETTING BY MORE THAN 5 DIGITS.

Figure 5-6. Calibration Linearity Check.



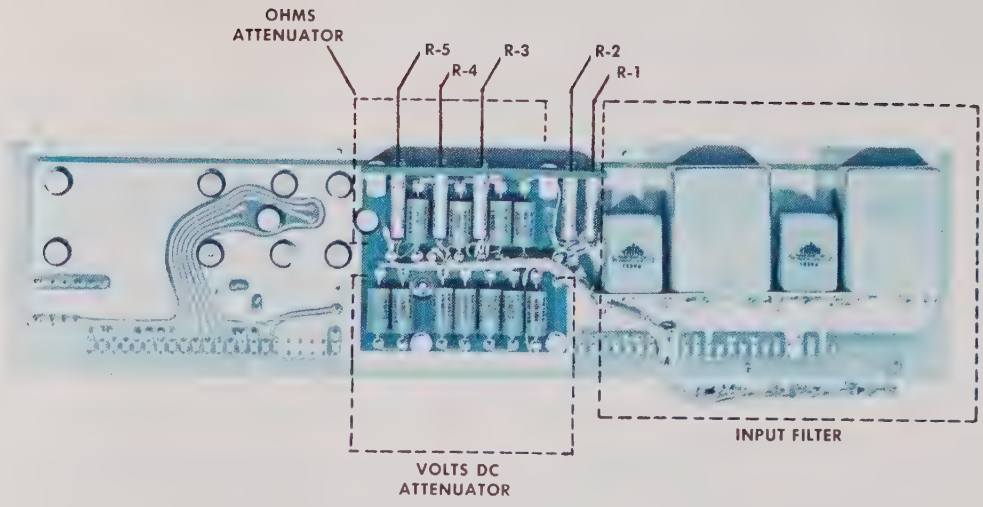
10070-109 MAIN BOARD ASSEMBLY, "B" UNIT

CIRCUIT REFERENCE	PART NUMBER	DESCRIPTION	QTY. PER UNIT	MANUFACTURER
J24	973102A-14S-5S-426	CONNECTOR, (5 PIN)	1	AMPHENOL
J23	973102A-14S-7P-426	CONNECTOR, (3 PIN)	1	AMPHENOL
J22	973102A-14S-2P-426	CONNECTOR, (4 PIN)	1	AMPHENOL
J20	500C-34X2-JR	CONNECTOR	1	C.E.C.
J21	500C-50X2-JR	CONNECTOR	1	C.E.C.
S5	10019-026	MODE, (3 POS.)	1	NLS
S4	10070-149	FILTER, (3 POS.)	1	NLS
S2/S3	10070-148	RANGE/FUNCTION, (5 POS.)	2	NLS
S1	10070-147	SWITCH, POWER, (3 POS.)	1	NLS
T1	10070-134	TRANSFORMER	1	NLS
C12 & C13	60B41	CAPACITOR, 10μf, 600V	2	IND. COND. CORP.
C10 & C11	1B1249	CAPACITOR, 250/250/250μf, 50V	2	IND. COND. CORP.
C5-C9	30B313	CAPACITOR, 200μf, 350V	5	IND. COND. CORP.
C3 & C4	1B1246	CAPACITOR, 4000μf, 25V	2	IND. COND. CORP.
C1 & C2	1B1245	CAPACITOR, 2000μf, 50V	2	IND. COND. CORP.
F1 & SPARE	313001	FUSE, 3AG—1 AMP SLO-BLO	2	LITTELFUSE



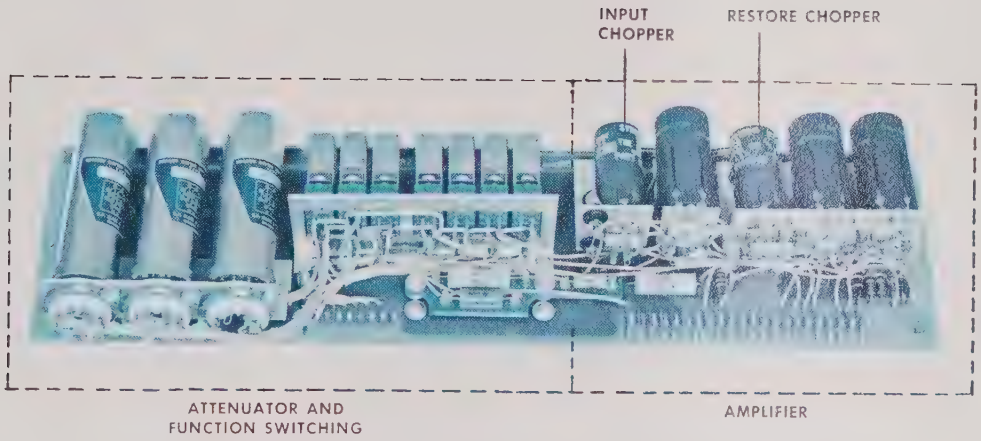
10070-009 MAIN BOARD ASSEMBLY, "A" UNIT

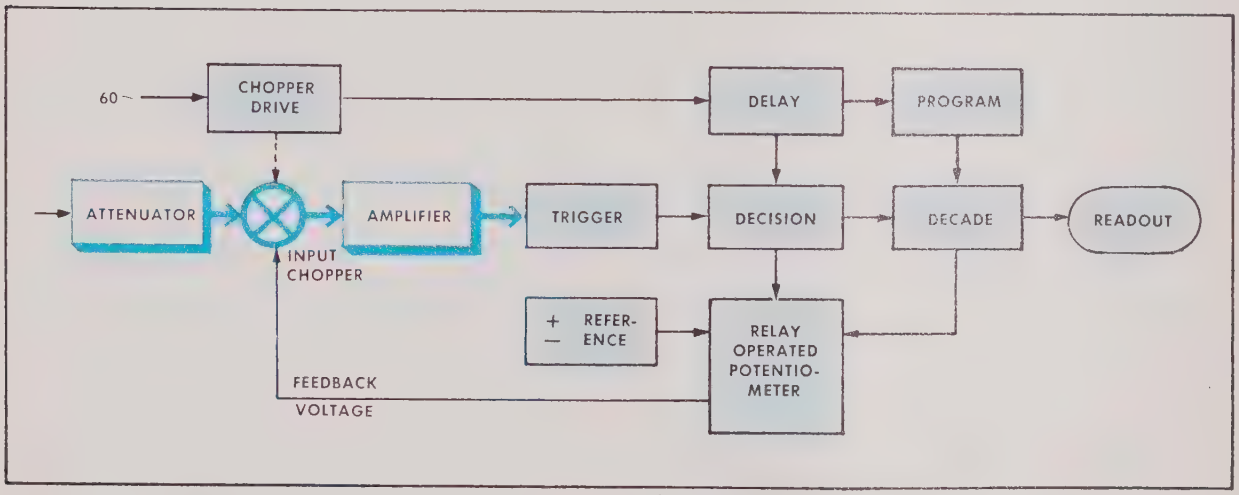
CIRCUIT REFERENCE	PART NUMBER	DESCRIPTION	QTY. UNIT PER	MANUFACTURER
R33-R44	PW1719	RESISTOR, 40K ±.005%	12	NLS
R29 & R30	PW1719	RESISTOR, 8K ±.01%	2	NLS
R25-R28	PW1719	RESISTOR, 4K ±.02%	4	NLS
R31 & R32	PW1719	RESISTOR, 2K ±.03%	2	NLS
R21 & R22	PW1719	RESISTOR, 800Ω ±.1%	2	NLS
R17-R20	PW1719	RESISTOR, 400Ω ±.1%	4	NLS
R23 & R24	PW1719	RESISTOR, 200Ω ±.1%	2	NLS
R13 & R14	PW1719	RESISTOR, 80Ω ±.1Ω	2	NLS
R9-R12	PW1719	RESISTOR, 40Ω ±.1Ω	4	NLS
R15 & R16	PW1719	RESISTOR, 20Ω ±.1Ω	2	NLS
R5 & R6	PW1719	RESISTOR, 8Ω ±.1Ω	2	NLS
R1-R4	PW1719	RESISTOR, 4Ω ±.1Ω	4	NLS
R7 & R8	PW1719	RESISTOR, 2Ω ±.1Ω	2	NLS
R45	49M9-50	POTENTIOMETER	1	CLAROSTAT
K1-K22		RELAY, NLS DOC. #378	22	C. P. CLARE
CR1-CR22	5003-002	DIODE	22	NLS



10070-117 AMPLIFIER-RANGE ASSEMBLY

CIRCUIT REFERENCE	PART NUMBER	DESCRIPTION	QTY. PER UNIT	MANUFACTURER
R34	EB2251	RESISTOR, 2.2 MEG, ±10%, ½W	1	ALLEN BRADLEY
R33	EB4721	RESISTOR, 4.7K, ±10%, ½W	1	ALLEN BRADLEY
R21	EB6235	RESISTOR, 62K, ±5%, ½W	1	ALLEN BRADLEY
R24	EB1305	RESISTOR, 13Ω, ±5%, 1W	1	ALLEN BRADLEY
R29 & R30	EB2231	RESISTOR, 22K, ±10%, ½W	2	ALLEN BRADLEY
R20	EB2731	RESISTOR, 270K, ±10%, 1W	1	ALLEN BRADLEY
R22 & R23	EB3045	RESISTOR, 300K, ±5%, ½W	2	ALLEN BRADLEY
R27 & R28	MEBT-0	RESISTOR, 10K, ±1%, ¼W	2	I.R.C.
R7	MEBT-0	RESISTOR, 909K, ±1%, ¼W	1	I.R.C.
R25	MEFT-2	RESISTOR, 182K, ±1%, 1W	1	I.R.C.
R32	MEBT-0	RESISTOR, 120K, ±1%, ¼W	1	I.R.C.
R31	MEFT-2	RESISTOR, 909K, ±1%, 1W	1	I.R.C.
R26	MEBT-0	RESISTOR, 806K, ±1%, ¼W	1	I.R.C.
R19	AW1224	RESISTOR, 200.1K, ±.03%	1	NLS
R6	303-00-100K	POTENTIOMETER	1	DAYSTROM PACIFIC
CR1	IN458	DIODE	1	HUGHES
C5	DD201	CAPACITOR, 200μf, ±10%, 1000 VDC	1	CENTRALAB
C3 & C4	92M2222	CAPACITOR, .0022μf, ±20%, 200 VDC	2	WESTCAP
C6	DE2-682E	CAPACITOR, .0068μf, ±10%, 200 VDC	1	ELECTRON
L1 & L2	15594	INDUCTOR	2	TRIAD
C1 & C2	MW1138	CAPACITOR, 1.0μf, ±10%, 1000 VDC	2	ELPAC
V5	6201	TUBE, TWIN TRIODE	1	R.C.A.
V4	5879	TUBE, PENTODE	1	R.C.A.
V3	GB-5751	TUBE, TWIN TRIODE	1	SYLVANIA
V1 & V2	NE-2	LAMP, NEON	2	G.E.
K11-K12	C1417-27	CHOPPER	2	BRISTOL
K4-K10		RELAY, NLS SPEC #383	7	BABCOCK
K1-K3		RELAY, NLS SPEC #378	3	C. P. CLARE





Digits (VDC and RATIO).

10070-143 RANGE ASSEMBLY

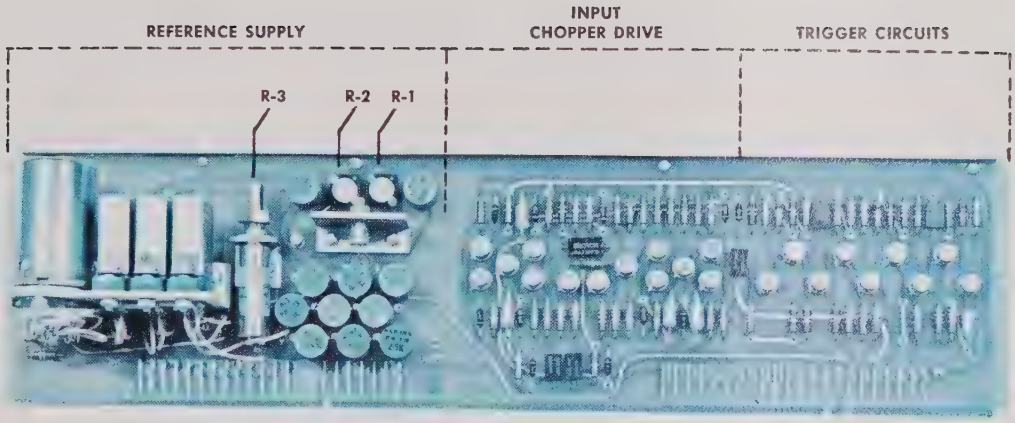
CIRCUIT REFERENCE	PART NUMBER	DESCRIPTION	QTY. PER UNIT	MANUFACTURER
R2 & R3	0250L-1-1KΩ	POTENTIOMETER, 1K	2	CONELCO
R1 & R4	0250L-1-100Ω	POTENTIOMETER, 100Ω	2	CONELCO
R5	0250L-1-10Ω	POTENTIOMETER, 10Ω	1	CONELCO
R18	AW1224	RESISTOR, 10K ±.03%	1	NLS
R16	AW1224	RESISTOR, 100K, ±.03%	1	NLS
R15	AW1224	RESISTOR, 100.18K, ±.03%	1	NLS
R14	AW1224	RESISTOR, 901.5K, ±.03%	1	NLS
R17	AW1224	RESISTOR, 1.0 MEG, ±.03%	1	NLS
R8-R13	AW1224	RESISTOR, 1.5 MEG, ±.03%	6	NLS

10070-113 REFERENCE SUPPLY BOARD ASSEMBLY

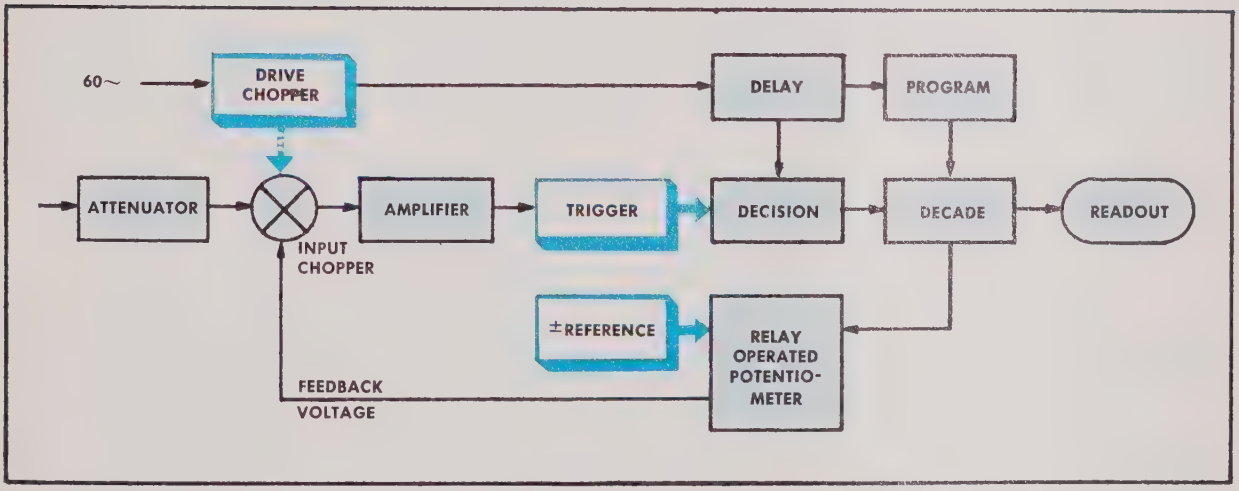
CIRCUIT REFERENCE	PART NUMBER	DESCRIPTION	QTY. PER UNIT	MANUFACTURER
K1, K2, K3		RELAY, PER NLS SPEC. 383	3	BABCOCK
V1	NE-2	LAMP, NEON	1	G.E.
CR13-CR17	IN2616	DIODE, WITH MYLAR SLEEVE	5	MOTOROLA
CR2-CR12	5003-002	DIODE	11	NLS
CR1	IN429	DIODE, ZENER	1	HOFFMAN
R12	PW1719	RESISTOR, 625Ω, ±1%	1	NLS
R6	PW1719	RESISTOR, 350Ω, ±1%	1	NLS
R67, R68	EB1315	RESISTOR, 130Ω, ±5%, ½W	2	ALLEN BRADLEY
R15	EB2241	RESISTOR, 220K, ±10%, ½W	1	ALLEN BRADLEY
R7	PW1719	RESISTOR, 40K, ±.05%	1	NLS
R59-R63	EB3331	RESISTOR, 33K, ±10%, ½W	5	ALLEN BRADLEY
R9	PW1719	RESISTOR, 20K, ±.1%	1	NLS
R64-R66	EB1531	RESISTOR, 15K, ±10%, ½W	3	ALLEN BRADLEY
R10	PW1719	RESISTOR, 10K, ±.1%	1	NLS
R27-R32	EB1031	RESISTOR, 10K, ±10%, ½W	6	ALLEN BRADLEY
R55-R58	EB8221	RESISTOR, 8.2K, ±10%, ½W	4	ALLEN BRADLEY
R52-R53	EB6821	RESISTOR, 6.8K, ±10%, ½W	2	ALLEN BRADLEY
R37-R39	EB5621	RESISTOR, 5.6K, ±10%, ½W	3	ALLEN BRADLEY
R11	PW1719	RESISTOR, 5.0K, ±.5%	1	NLS
R33-R36	EB3921	RESISTOR, 3.9K, ±10%, ½W	4	ALLEN BRADLEY
R4, R5	PW1719	RESISTOR, 3.5K, ±1%	2	NLS
R40-R51	EB3321	RESISTOR, 3.3K, ±10%, ½W	12	ALLEN BRADLEY
R22-R26	EB2721	RESISTOR, 2.7K, ±10%, ½W	5	ALLEN BRADLEY
R14	PW1719	RESISTOR, 2.5K, ±1%	1	NLS
R16-R21	EB1621	RESISTOR, 1.6K, ±10%, ½W	6	ALLEN BRADLEY
R8	PW1719	RESISTOR, 1.5K, ±1%	1	NLS
R13	PW1719	RESISTOR, 1.25K, ±1%	1	NLS
R54	EB1021	RESISTOR, 1.0K ±10%, ½W	1	ALLEN BRADLEY
R3	SM-5000	POTENTIOMETER, 1KΩ	1	CIRCUIT INSTR.
R1, R2	300-00-100	POTENTIOMETER, 100Ω	2	DAYSTROM PACIFIC
C5, C6	DE2-682E	CAPACITOR, .0068μf, ±10%, 200 VDC	2	ELECTRON
C2, C3, C4	DE2-223E	CAPACITOR, .022μf, ±10%, 200 VDC	3	ELECTRON
C1	DE2-473E	CAPACITOR, .047μf, ±10%, 200 VDC	1	ELECTRON
Q23	2N600	TRANSISTOR	1	PHILCO
Q1-Q22	2N651	TRANSISTOR	22	MOTOROLA
HR1	10050-026	OVEN ASSY	1	NLS

10070-119 RECTIFIER BOARD ASSEMBLY

F1-F3	313002	FUSE, 2A-3AG, SLO-BLO	8	LITTELFUSE
CR23-CR28	IN1124R	DIODE	6	TEXAS INSTRUMENTS
CR19-CR22	1N3047B	DIODE	4	MOTOROLA
CR1-CR18	IN2616	DIODE, WITH SLEEVING (ALT: IN3256)	18	MOTOROLA
R7	EB1051	RESISTOR, 1 MEG ±10%, ½W	1	ALLEN BRADLEY
R1 & R2	EB4731	RESISTOR, 47K, ±10%, 2W	2	ALLEN BRADLEY
R3	EB3331	RESISTOR, 33K, ±10%, 2W	1	ALLEN BRADLEY
R4	EB1635	RESISTOR, 16K, ±5%, 1W	1	ALLEN BRADLEY
R5 & R6	EB2721	RESISTOR, 2.7K, ±10%, ½W	2	ALLEN BRADLEY
C1	DE2-105E	CAPACITOR, 1.0μf, ±10%, 200 VDC	1	ELECTRON

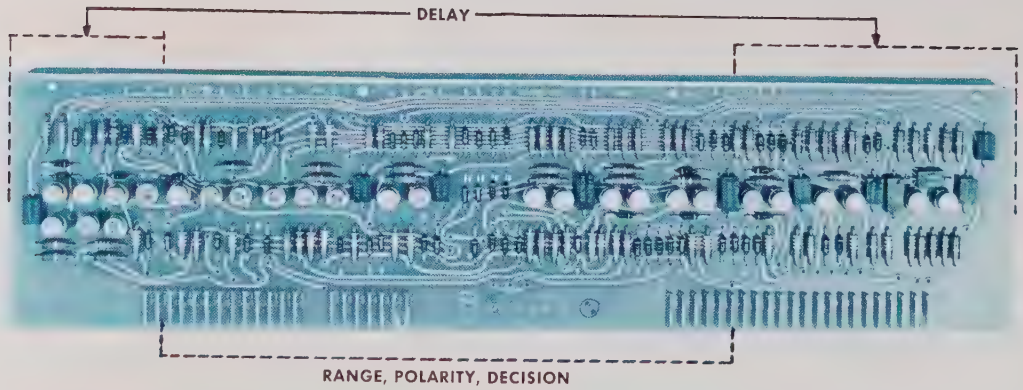


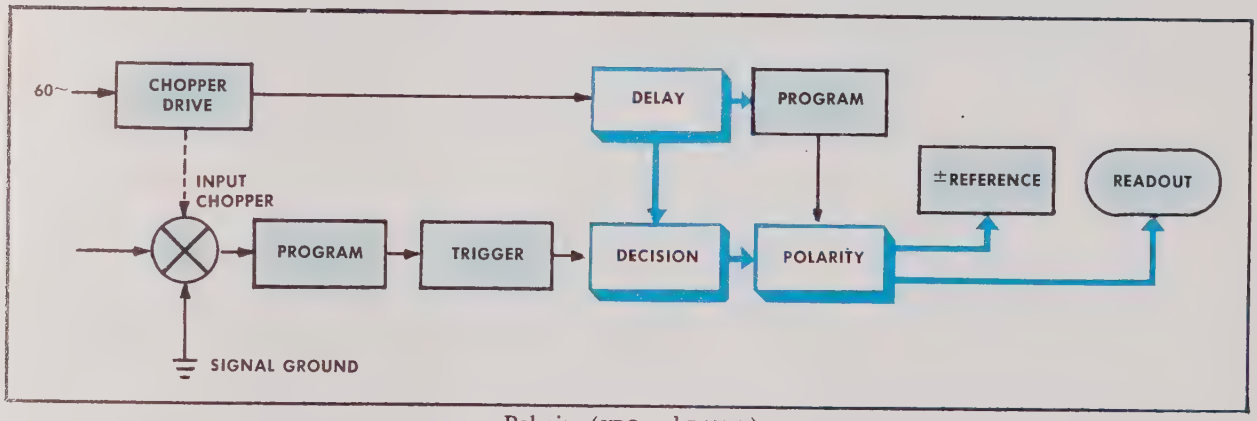
10070-113 REFERENCE SUPPLY BOARD ASSEMBLY



Digits (VDC and RATIO).

10070-119 RECTIFIER BOARD ASSEMBLY

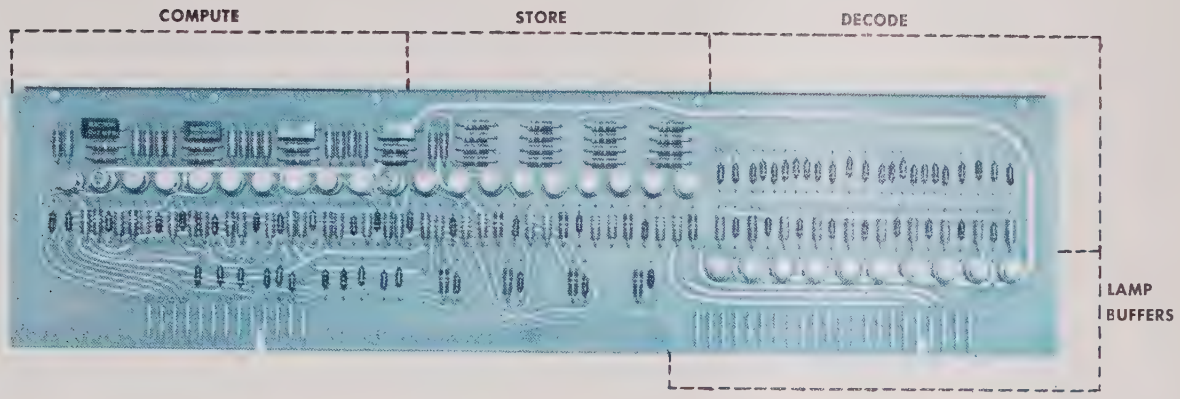


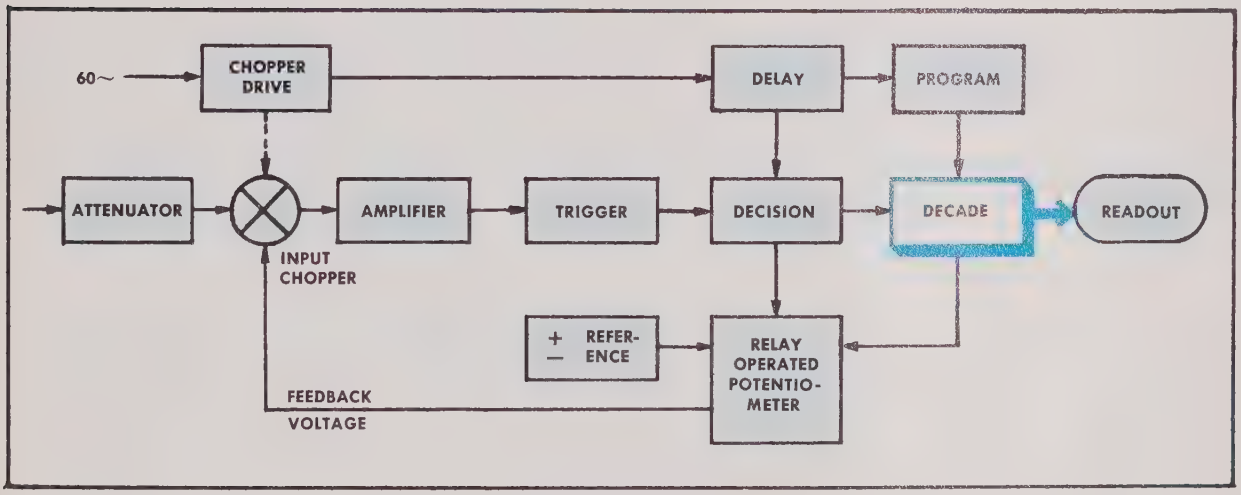


Polarity (VDC and RATIO)

10070-017 POLARITY-DECISION BOARD ASSEMBLY

CIRCUIT REFERENCE	PART NUMBER	DESCRIPTION	QTY. PER UNIT	MANUFACTURER
CR62-CR64	IN625	DIODE	3	HUGHES
CR1-CR61	5003-002	DIODE	61	NLS
R1-R18	EB3331	RESISTOR, 33K, ±10%, ½W	18	ALLEN BRADLEY
R84-R87	EB2231	RESISTOR, 22K, ±10%, ½W	4	ALLEN BRADLEY
R47-R50	EB1531	RESISTOR, 15K, ±10%, ½W	4	ALLEN BRADLEY
R43-R46	EB1031	RESISTOR, 10K, ±10%, ½W	4	ALLEN BRADLEY
R19	EB8221	RESISTOR, 8.2K, ±10%, ½W	1	ALLEN BRADLEY
R20-R42	EB5621	RESISTOR, 5.6K, ±10%, ½W	23	ALLEN BRADLEY
R63-R69	EB5125	RESISTOR, 5.1K, ±5%, ½W	7	ALLEN BRADLEY
R80-R83	EB4721	RESISTOR, 4.7K, ±10%, ½W	4	ALLEN BRADLEY
R60-R62	EB3921	RESISTOR, 3.9K, ±10%, ½W	3	ALLEN BRADLEY
R58 & R59	EB3625	RESISTOR, 3.6K, ±5%, ½W	2	ALLEN BRADLEY
R70-R79	EB2721	RESISTOR, 2.7K, ±10%, ½W	10	ALLEN BRADLEY
R51-R57	EB2221	RESISTOR, 2.2K, ±10%, ½W	7	ALLEN BRADLEY
C9-C11	DE2-473E	CAPACITOR, .047μf, ±10%, 200 VDC	3	ELECTRON
C5-C8	DE2-223E	CAPACITOR, .022μf, ±10%, 200 VDC	4	ELECTRON
C1-C4	DE2-682E	CAPACITOR, .0068μf, ±10%, 200 VDC	4	ELECTRON
Q1-Q27	2N651	TRANSISTOR	27	MOTOROLA

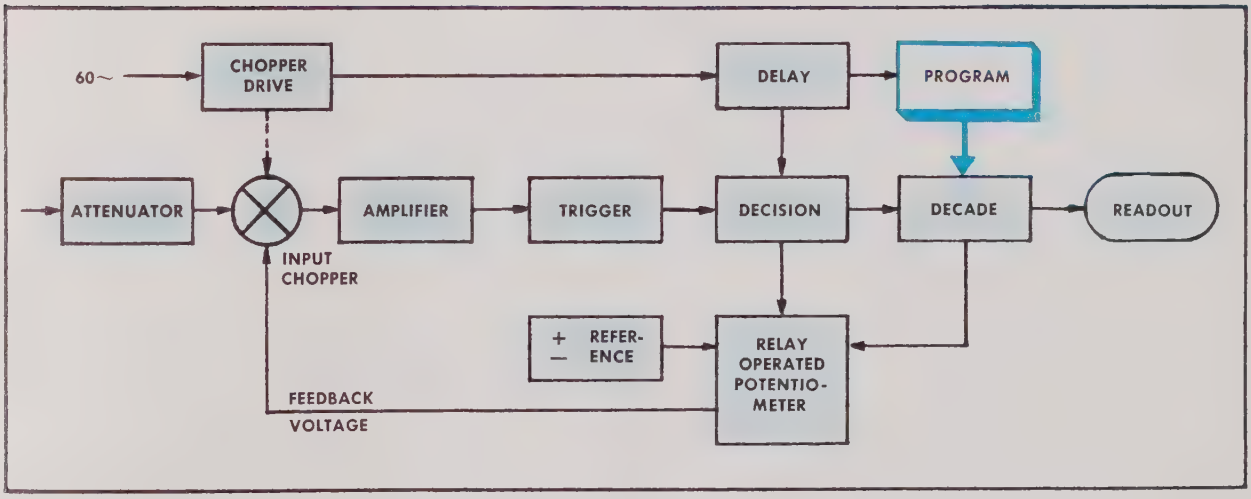




Digits (VDC and RATIO).

10070-011 DECADE BOARD ASSEMBLY

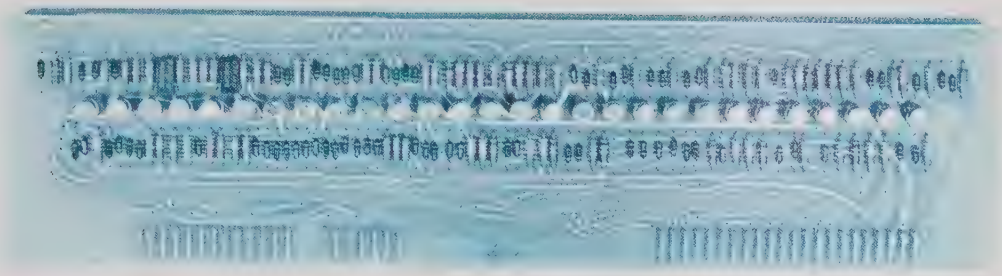
CIRCUIT REFERENCE	PART NUMBER	DESCRIPTION	QTY. PER UNIT	MANUFACTURER
CR60-CR63	IN625	DIODE	4	HUGHES
CR1-CR59	5003-002	DIODE	59	NLS
R71-R78	EB3331	RESISTOR, 33K, ±10%, ½W	8	ALLEN BRADLEY
R47-R54	EB2231	RESISTOR, 22K, ±10%, ½W	8	ALLEN BRADLEY
R79-R86	EB1031	RESISTOR, 10K, ±10%, ½W	8	ALLEN BRADLEY
R31-R38	EB5125	RESISTOR, 5.1K, ±5%, ½W	8	ALLEN BRADLEY
R39-R46	EB4721	RESISTOR, 4.7K, ±10%, ½W	8	ALLEN BRADLEY
R55-R62	EB3921	RESISTOR, 3.9K, ±10%, ½W	8	ALLEN BRADLEY
R1-R14	EB3625	RESISTOR, 3.6K, ±5%, ½W	14	ALLEN BRADLEY
R15-R30	EB2721	RESISTOR, 2.7 K, ±10%, ½W	16	ALLEN BRADLEY
R63-R70	EB2221	RESISTOR, 2.2K, ±10%, ½W	8	ALLEN BRADLEY
C1-C4	DE2-473E	CAPACITOR, .047μf, ±10%, 200 VDC	4	ELECTRON
Q1-Q30	2N651	TRANSISTOR	30	MOTOROLA

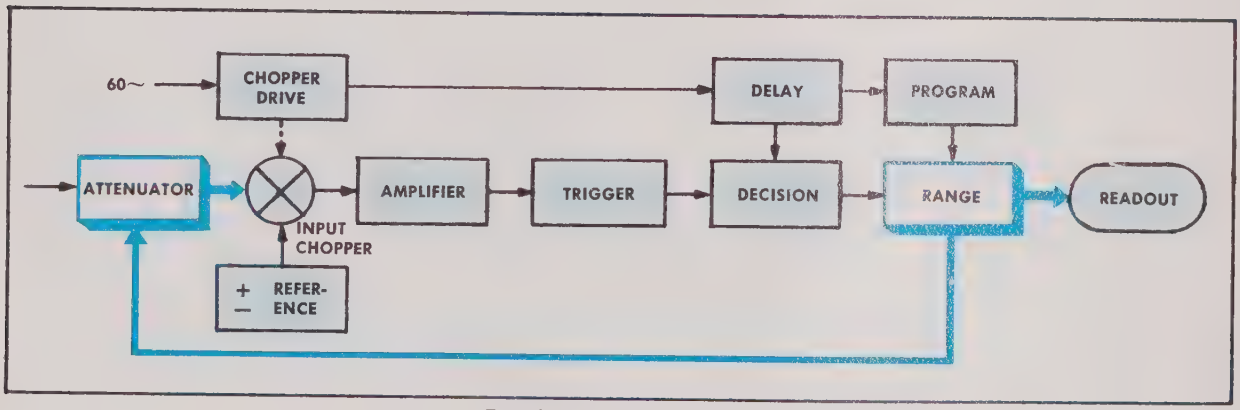


Digits (VDC and RATIO)

10070-013 6 STAGE COUNTER BOARD ASSEMBLY

CIRCUIT REFERENCE	PART NUMBER	DESCRIPTION	QTY. PER UNIT	MANUFACTURER
CR1-CR12	IN625	DIODE	12	HUGHES
CR13-CR126	5003-002	DIODE	114	NLS
R13-R32	EB3331	RESISTOR, 33K, ±10%, ½W	20	ALLEN BRADLEY
R59-R72	EB1531	RESISTOR, 15K, ±10%, ½W	14	ALLEN BRADLEY
R87 & R88	EB1031	RESISTOR, 10K, ±10%, ½W	2	ALLEN BRADLEY
R46	EB8221	RESISTOR, 8.2K, ±10%, ½W	1	ALLEN BRADLEY
R33-R45	EB5621	RESISTOR, 5.6K, ±10%, ½W	13	ALLEN BRADLEY
R73-R84	EB3321	RESISTOR, 3.3K, ±10%, ½W	12	ALLEN BRADLEY
R85 & R86	EB2721	RESISTOR, 2.7K, ±10%, ½W	2	ALLEN BRADLEY
R9-R12	EB2221	RESISTOR, 2.2K, ±10%, ½W	4	ALLEN BRADLEY
R47-R58	EB1821	RESISTOR, 1.8K, ±10%, ½W	12	ALLEN BRADLEY
R1-R8	EB1021	RESISTOR, 1.0K, ±10%, ½W	8	ALLEN BRADLEY
C1-C15	DE2-223E	CAPACITOR, .022μf, ±10%, 200 VDC	15	ELECTRON
Q1-Q24	2N651	TRANSISTOR	24	MOTOROLA

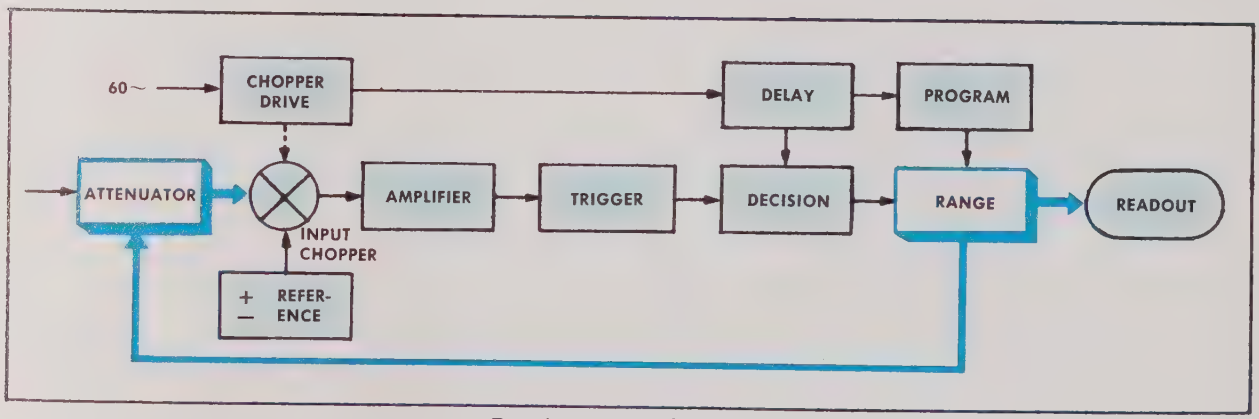




Ranging (VDC and RATIO).

10070-015 RANGE-FUNCTION BOARD ASSEMBLY

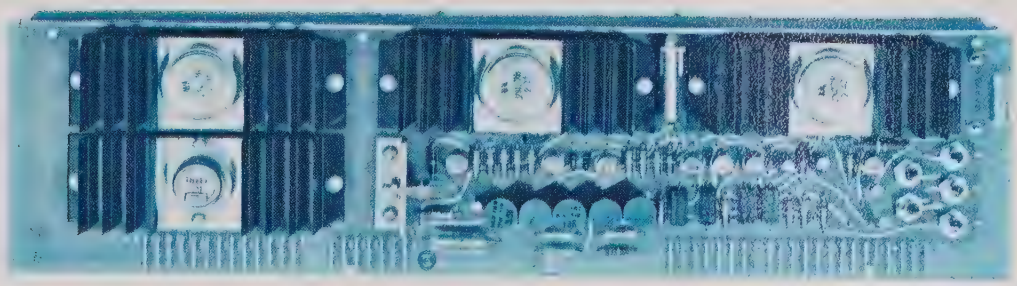
CIRCUIT REFERENCE	PART NUMBER	DESCRIPTION	QTY. PER UNIT	MANUFACTURER
CR65-CR68	IN625	DIODE	4	HUGHES
CR1-CR64	5003-002	DIODE	66	NLS
R55-R69	EB3331	RESISTOR, 33K, ±10%, ½W	15	ALLEN BRADLEY
R74-R77	EB2231	RESISTOR, 22K, ±10%, ½W	4	ALLEN BRADLEY
R1-R10	EB1031	RESISTOR, 10K, ±10%, ½W	10	ALLEN BRADLEY
R22-R25	EB5621	RESISTOR, 5 6K, ±10%, ½W	4	ALLEN BRADLEY
R26-R30	EB5125	RESISTOR, 5.1K, ±5%, ½W	5	ALLEN BRADLEY
R70-R73	EB4721	RESISTOR, 4.7K, ±10%, ½W	4	ALLEN BRADLEY
R39-R46	EB3921	RESISTOR, 3.9K, ±10%, ½W	8	ALLEN BRADLEY
R11-R21	EB3625	RESISTOR, 3.6K, ±5%, ½W	11	ALLEN BRADLEY
R31-R38	EB2721	RESISTOR, 2.7K, ±10%, ½W	8	ALLEN BRADLEY
R47-R54	EB2221	RESISTOR, 2.2K, ±10%, ½W	8	ALLEN BRADLEY
R78	EB1821	RESISTOR, 1.8K, ±10%, ½W	1	ALLEN BRADLEY
C1 & C2	DE2-473E	CAPACITOR, .047μf, ±10%, 200 VDC	2	ELECTRON
Q1-Q28	2N651	TRANSISTOR	28	MOTOROLA



Ranging (VDC and RATIO).

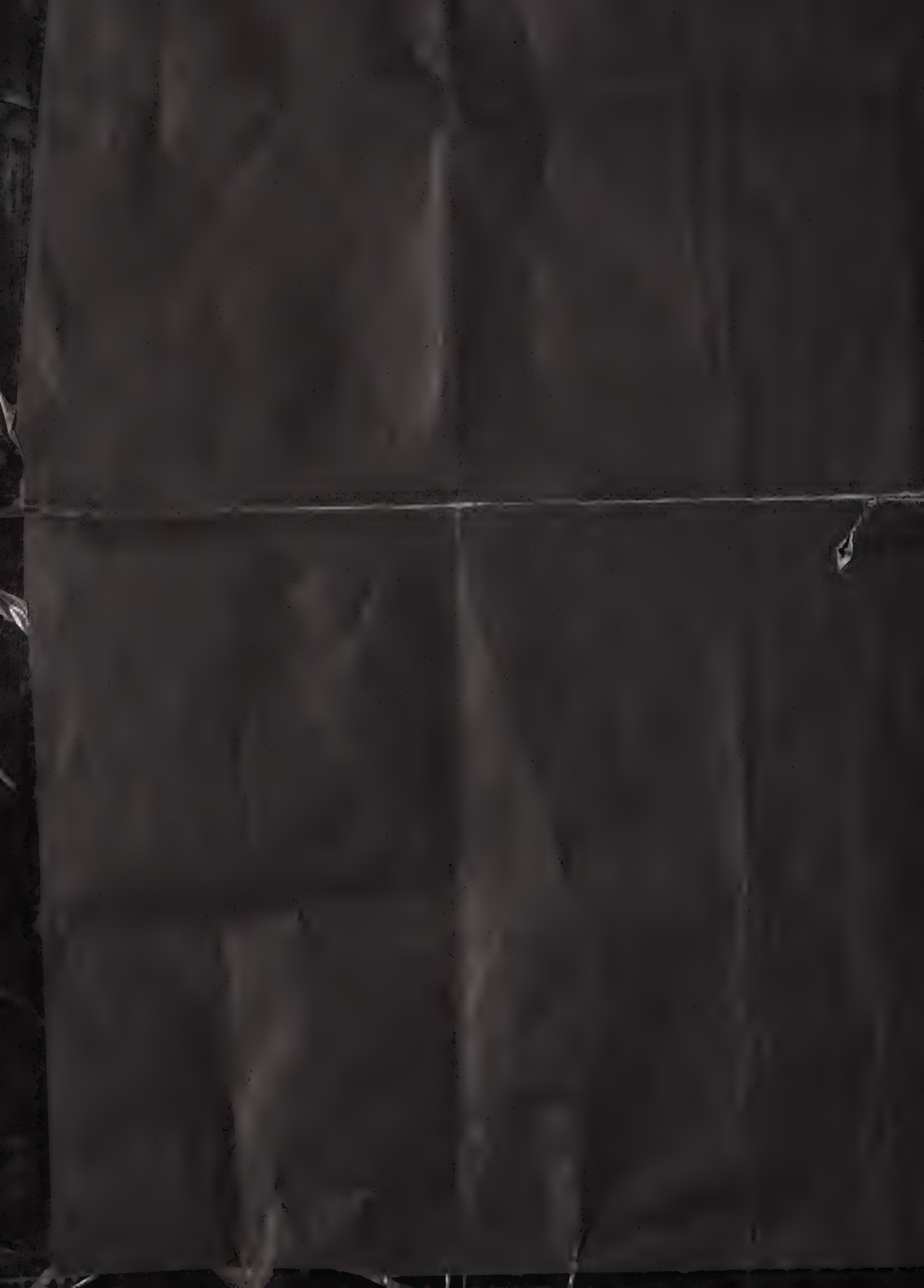
10070-115 BUFFER BOARD ASSEMBLY

CIRCUIT REFERENCE	PART NUMBER	DESCRIPTION	QTY. PER UNIT	MANUFACTURER
CR1-CR46	5003-002	DIODE	46	NLS
R61-R64	EB3331	RESISTOR, 33K, ±10%, ½W	4	ALLEN BRADLEY
R20-R24	EB1531	RESISTOR, 15K, ±10%, ½W	5	ALLEN BRADLEY
R58-R60	EB1031	RESISTOR, 10K, ±10%, ½W	3	ALLEN BRADLEY
R25-R31	EB8221	RESISTOR, 8.2K, ±10%, ½W	7	ALLEN BRADLEY
R32-R40	EB5621	RESISTOR, 5.6K, ±10%, ½W	9	ALLEN BRADLEY
R50-R54	EB4721	RESISTOR, 4.7K, ±10%, ½W	5	ALLEN BRADLEY
R1-R14	EB3625	RESISTOR, 3.6K, ±5%, ½W	14	ALLEN BRADLEY
R41-R49	EB2721	RESISTOR, 2.7K, ±10%, ½W	9	ALLEN BRADLEY
R15-R19	EB2221	RESISTOR, 2.2K, ±10%, ½W	5	ALLEN BRADLEY
R55-R57	EB4711	RESISTOR, 470Ω, ±10%, ½W	3	ALLEN BRADLEY
Q1-Q30	2N651	TRANSISTOR	30	MOTOROLA



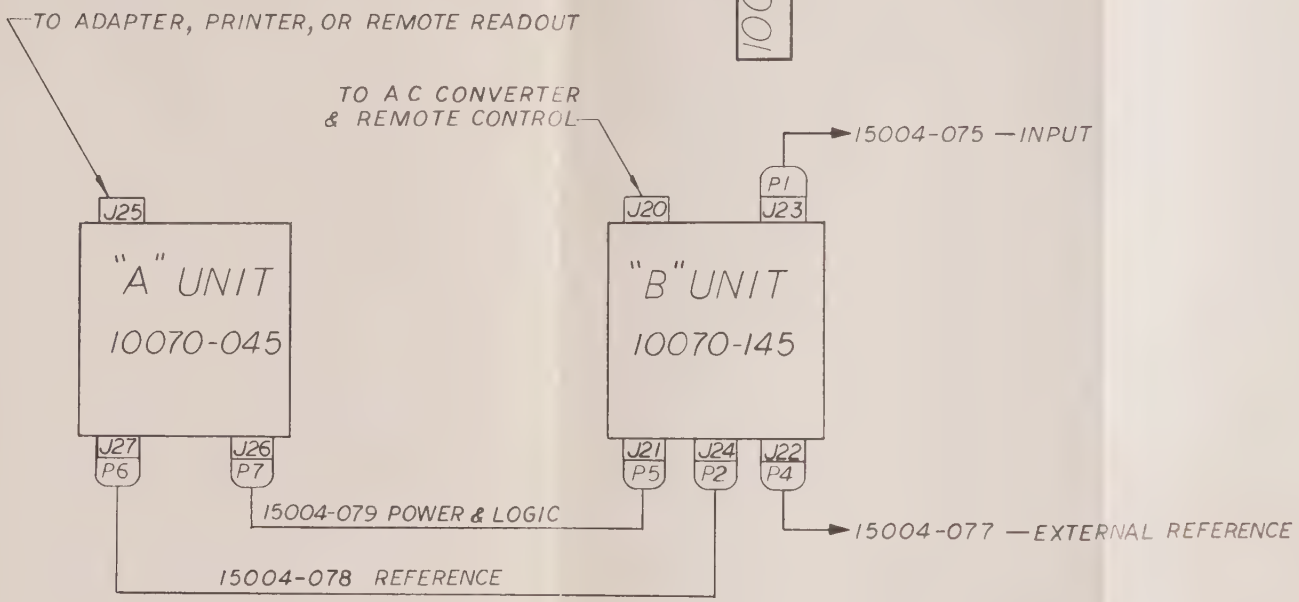
10070-111 POWER SUPPLY BOARD ASSEMBLY

CIRCUIT REFERENCE	PART NUMBER	DESCRIPTION	QTY. PER UNIT	MANUFACTURER
CR6	IN3033B	DIODE, ZENER	1	MOTOROLA
CR7-CR11	IN1124R	DIODE	5	TEXAS INSTRUMENTS
CR3-CR5	IN429	DIODE, ZENER	3	HOFFMAN
CR1 & CR2	5003-002	DIODE	2	NLS
R1	0250L-1-200Ω	POTENTIOMETER, 200Ω	1	CONELCO
R17 & R18	EB3341	RESISTOR, 330K, ±10%, ½W	2	ALLEN BRADLEY
R16	EB6831	RESISTOR, 68K, ±10%, ½W	1	ALLEN BRADLEY
R9-R11	EB2731	RESISTOR, 27K, ±10%, ½W	3	ALLEN BRADLEY
R2	EB1635	RESISTOR, 16K, ±5%, ½W	1	ALLEN BRADLEY
R12 & R13	EB8221	RESISTOR, 8.2K, ±10%, ½W	2	ALLEN BRADLEY
R4-R7	EB6821	RESISTOR, 6.8K, ±10%, ½W	4	ALLEN BRADLEY
R15	EB2721	RESISTOR, 2.7K, ±10%, ½W	1	ALLEN BRADLEY
R19	EB2025	RESISTOR, 2K, ±5%, ½W	1	ALLEN BRADLEY
R14	EB1021	RESISTOR, 1K, ±10%, ½W	1	ALLEN BRADLEY
R20	EB8211	RESISTOR, 820Ω, ±10%, ½W	1	ALLEN BRADLEY
R8	EB4711	RESISTOR, 470Ω, ±10%, ½W	1	ALLEN BRADLEY
R3	EB2701	RESISTOR, 27Ω, ±10%, ½W	1	ALLEN BRADLEY
R21	PW1719	RESISTOR, 3.8K, ±1%, ½W	1	NLS
R24 & R25	PW1719	RESISTOR, 2.9K, ±.5%, ½W	2	NLS
R23	PW1719	RESISTOR, 1.3K, ±1%, ½W	1	NLS
R22	PW1719	RESISTOR, 1.0K, ±1%, ½W	1	NLS
C5 & C9	SCM476HP035D2	CAPACITOR, 47μf, ±10%, 35 VDC	2	TEXAS INSTRUMENTS
C6-C8	SCM475BP035D2	CAPACITOR, 4.7μf, ±10%, 35 VDC	3	TEXAS INSTRUMENTS
C1-C4	DE2-473E	CAPACITOR, .047μf, ±10%, 200 VDC	4	ELECTRON
Q6	2N1305	TRANSISTOR	1	TEXAS INSTRUMENTS
Q7 & Q8	2N1302	TRANSISTOR	1	TEXAS INSTRUMENTS
Q9-Q12	2N651	TRANSISTOR	4	MOTOROLA
Q5	2N600	TRANSISTOR	1	PHILCO
Q4	2N553	TRANSISTOR	1	DELCO
Q1-Q3	2N278	TRANSISTOR	3	MOTOROLA
Q13 & Q14	2N274	TRANSISTOR	2	RCA



10070 SHEET 4

REVISIONS			
SYM.	EFFECT.	DATE	APPROVAL



NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED	DRAWN BY H. BRINLEY	DATE 2-16-62	TITLE
DIMENSIONS ARE IN INCHES	CHECKED BY	DATE	CABLING DIAGRAM
TOLERANCES ON FRACTION ± DECIMAL ± ANGLES ±	APPROVED BY R. JOHNSON	DATE 2-21-62	MODEL M25
MATERIAL	FINISH		SCALE WT.

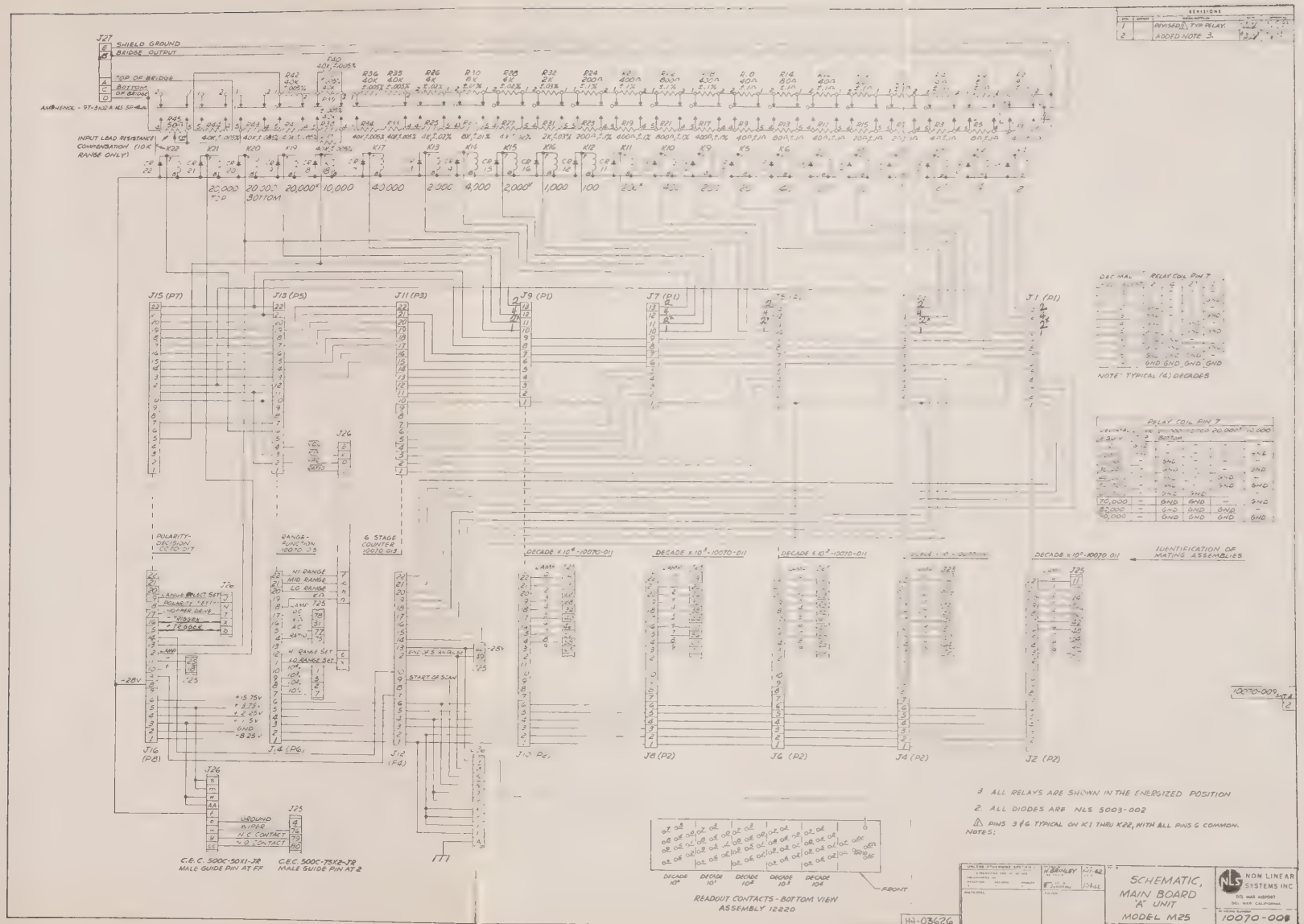
NON-LINEAR SYSTEMS INC.
DEL MAR AIRPORT
DEL MAR, CALIFORNIA

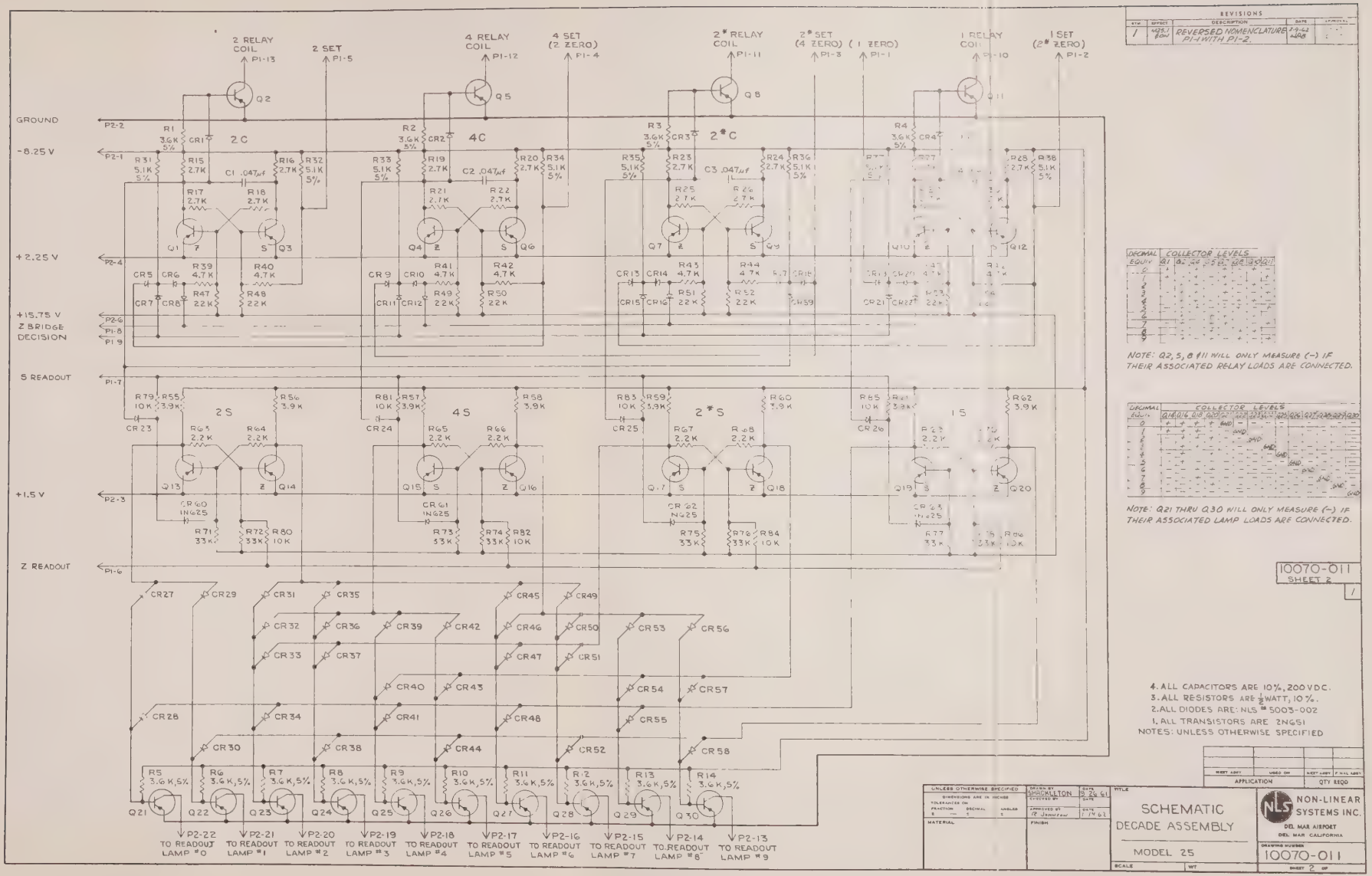
DRAWING NUMBER 10070

SHEET 4 OF

NOTE

1. MATING PLUGS FOR J20 & J25 ARE SUPPLIED WITH INSTRUMENT.


REVISIONS
1 REVISED J1, TYP RELAY.
2 ADDED NOTE 3.
J27
SHIELD GROUND
BRIDGE OUTPUT
TOP OF BRIDGE
BOTTOM OF BRIDGE
AMPHENOL - 97-3102 A 14S 5P-4
INPUT LEAD RESISTANCE COMPENSATION (10K RANGE ONLY)
20,000 TOP
20,000 BOTTOM
20,000*
10,000
4,000
2,500
1,000
100
J15 (P7)
J13 (P5)
J11 (P3)
J9 (P1)
J7 (P11)
J1 (P1)
J26
POLARITY-DECISION LOGIC 017
RANGE-FUNCTION LOGIC 015
6 STAGE COUNTER LOGIC 013
DECADE X 10⁴ - 10070-011
DECADE X 10³ - 10070-011
DECADE X 10² - 10070-011
DECADE X 10¹ - 10070-011
IDENTIFICATION OF MATING ASSEMBLIES
J16 (P8)
J14 (P6)
J12 (P4)
J10 P6
J8 (P2)
J6 (P2)
J4 (P2)
J2 (P2)
J25
J26
GROUND
WIPER
N.C. CONTACT
N.O. CONTACT
C.E.C. 500C-50X1-JR
MALE GUIDE PIN AT FF
C.E.C. 500C-75X2-JR
MALE GUIDE PIN AT 2
DECADE 10⁵
DECADE 10⁴
DECADE 10³
DECADE 10²
DECADE 10¹
FRONT
READOUT CONTACTS - BOTTOM VIEW
ASSEMBLY 12220
RELAY COIL PIN 7
DECIMAL
GND
10070-009
NOTES:
3 ALL RELAYS ARE SHOWN IN THE ENERGIZED POSITION
2. ALL DIODES ARE NLS 5003-002
⚠ PINS 3 & 6 TYPICAL ON K1 THRU K22, WITH ALL PINS 6 COMMON.
SCHEMATIC, MAIN BOARD 'A' UNIT MODEL M25
NON LINEAR SYSTEMS INC
DEL MAR AIRPORT
DEL MAR, CALIFORNIA
10070-009
H4-03626



REVISIONS				
STAT	EFFECT	DESCRIPTION	DATE	APPROVAL
1	423 / BOM	REVERSED NOMENCLATURE P1-1 WITH P1-2.	9-4-62 WDB	

DECIMAL EQUIV. — COLLECTOR LEVELS: Q1 Q2 Q3 Q4 Q5 Q6 Q7 Q8 Q9 Q10 Q11 Q12

NOTE: Q2, 5, 8 & 11 WILL ONLY MEASURE (-) IF THEIR ASSOCIATED RELAY LOADS ARE CONNECTED.

DECIMAL EQUIV. — COLLECTOR LEVELS: Q14 Q15 Q16 Q17 Q18 Q19 Q20 Q21 Q22 Q23 Q24 Q25 Q26 Q27 Q28 Q29 Q30

NOTE: Q21 THRU Q30 WILL ONLY MEASURE (-) IF THEIR ASSOCIATED LAMP LOADS ARE CONNECTED.

10070-011
SHEET 2
1

4. ALL CAPACITORS ARE 10%, 200 VDC.
3. ALL RESISTORS ARE ½ WATT, 10%.
2. ALL DIODES ARE: NLS # 5003-002
1. ALL TRANSISTORS ARE 2N651
NOTES: UNLESS OTHERWISE SPECIFIED

SHEET ASSY	USED ON	NEXT ASSY	P. N. NEXT ASSY
APPLICATION		QTY REQD	

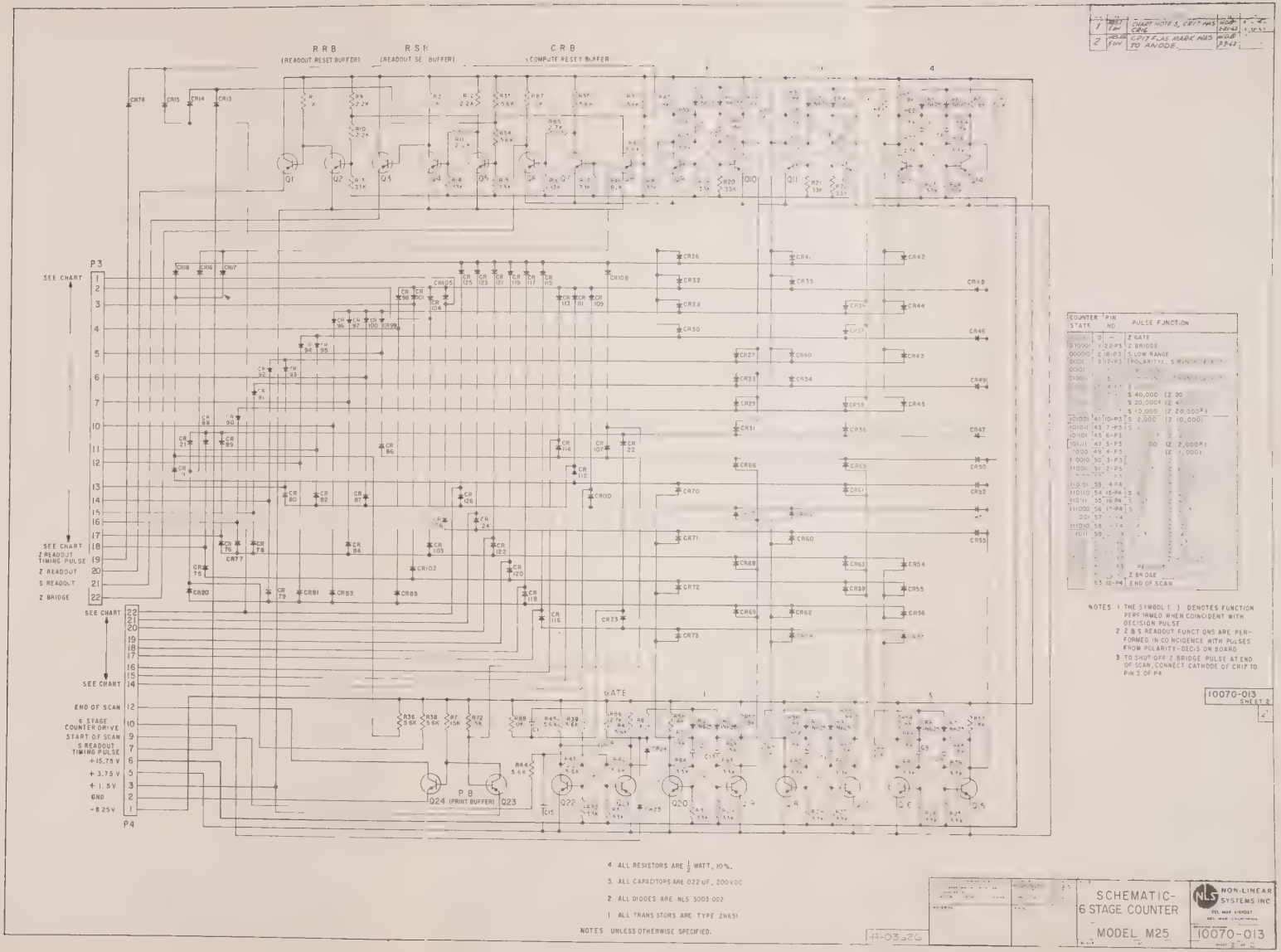
UNLESS OTHERWISE SPECIFIED — DIMENSIONS ARE IN INCHES — TOLERANCES ON FRACTION DECIMAL ANGLES — MATERIAL

DRAWN BY SHACKLETON DATE 10 26 61
CHECKED BY
APPROVED BY R Jamieson DATE 11 14 62
FINISH

TITLE: SCHEMATIC DECADE ASSEMBLY
MODEL 25
SCALE WT

NON-LINEAR SYSTEMS INC.
DEL MAR AIRPORT
DEL MAR CALIFORNIA

DRAWING NUMBER 10070-011
SHEET 2 OF



NOTES 1 THE SYMBOL ( ) DENOTES FUNCTION PERFORMED WHEN COINCIDENT WITH DECISION PULSE
2 Z B S READOUT FUNCTIONS ARE PERFORMED IN COINCIDENCE WITH PULSES FROM POLARITY-DECIS ON BOARD
3 TO SHUT OFF Z BRIDGE PULSE AT END OF SCAN, CONNECT CATHODE OF CR17 TO PIN 5 OF P4

10070-013 SHEET 2

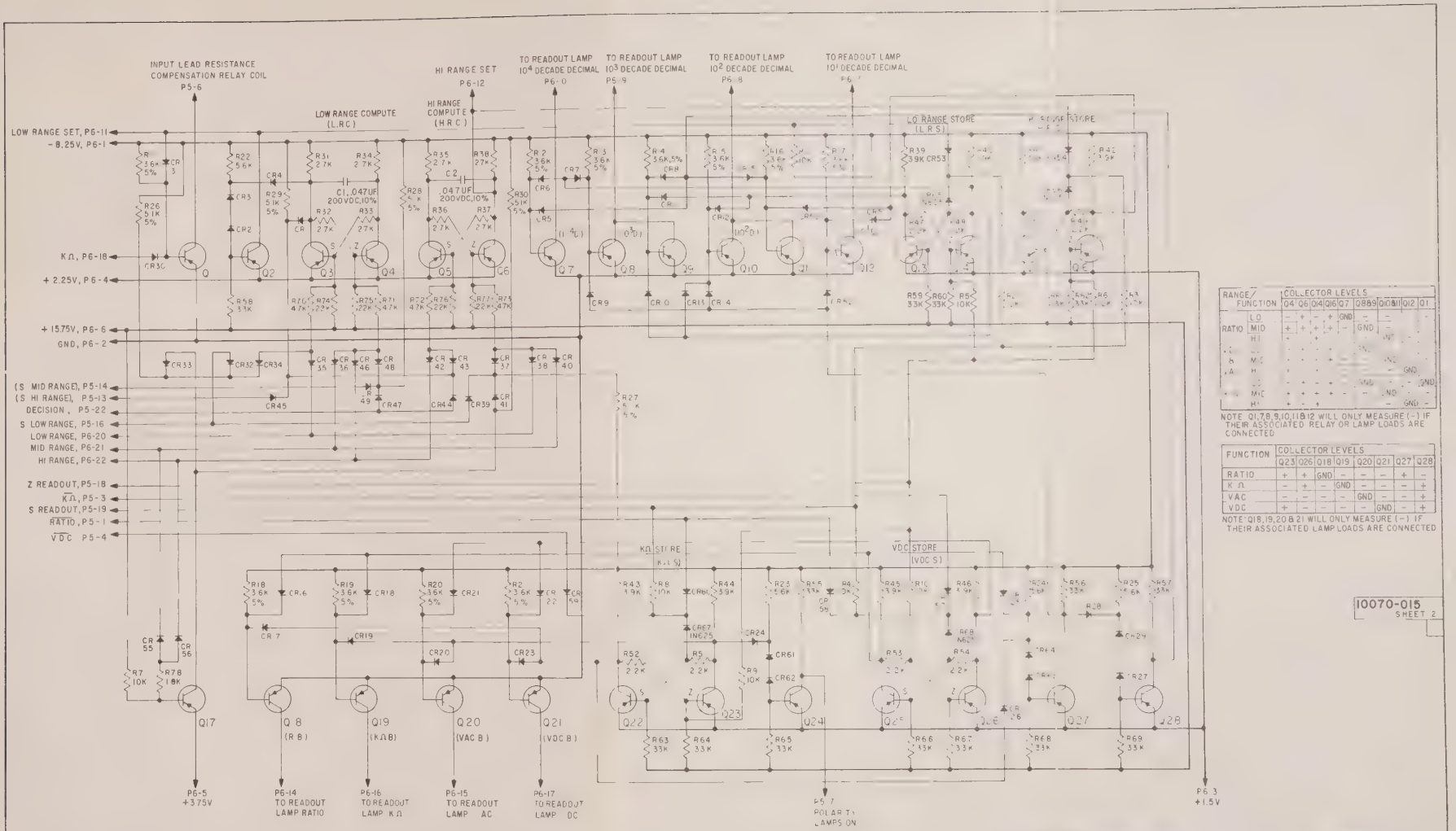
4 ALL RESISTORS ARE 1/8 WATT, 10%.
3. ALL CAPACITORS ARE .022 UF., 200 VDC
2 ALL DIODES ARE NLS 5003 002
1 ALL TRANSISTORS ARE TYPE 2N651
NOTES UNLESS OTHERWISE SPECIFIED.

11-03-26

SCHEMATIC-
6 STAGE COUNTER
MODEL M25

NON-LINEAR SYSTEMS INC

10070-013



RANGE / FUNCTION	COLLECTOR LEVELS Q4	Q6	Q14	Q16	Q7	Q8&9	Q10&11	Q12	Q1
RATIO	LO	–	+	–	+	GND	–	–	
	MID	+	+	+	+	–	GND	–	
	HI	+	–	+	–	+	–	–	
KΩ	LO	–	+	–	+	–	–	–	
	MID	+	+	+	+	–	–	GND	
	HI	+	–	+	–	+	–	–	GND
VAC	LO	–	+	–	+	–	–	–	
	MID	+	+	+	+	–	–	GND	
	HI	+	–	+	–	+	–	–	GND
VDC	LO	–	+	–	+	–	–	–	
	MID	+	+	+	+	–	–	GND	
	HI	+	–	+	–	+	–	–	GND

NOTE Q1,7,8,9,10,11&12 WILL ONLY MEASURE (–) IF THEIR ASSOCIATED RELAY OR LAMP LOADS ARE CONNECTED

FUNCTION	COLLECTOR LEVELS Q23	Q26	Q18	Q19	Q20	Q21	Q27	Q28
RATIO	+	+	GND	–	–	–	+	–
KΩ	–	+	–	GND	–	–	–	+
VAC	–	–	–	–	GND	–	–	+
VDC	+	–	–	–	–	GND	–	+

NOTE Q18,19,20&21 WILL ONLY MEASURE (–) IF THEIR ASSOCIATED LAMP LOADS ARE CONNECTED

10070-015 SHEET 2

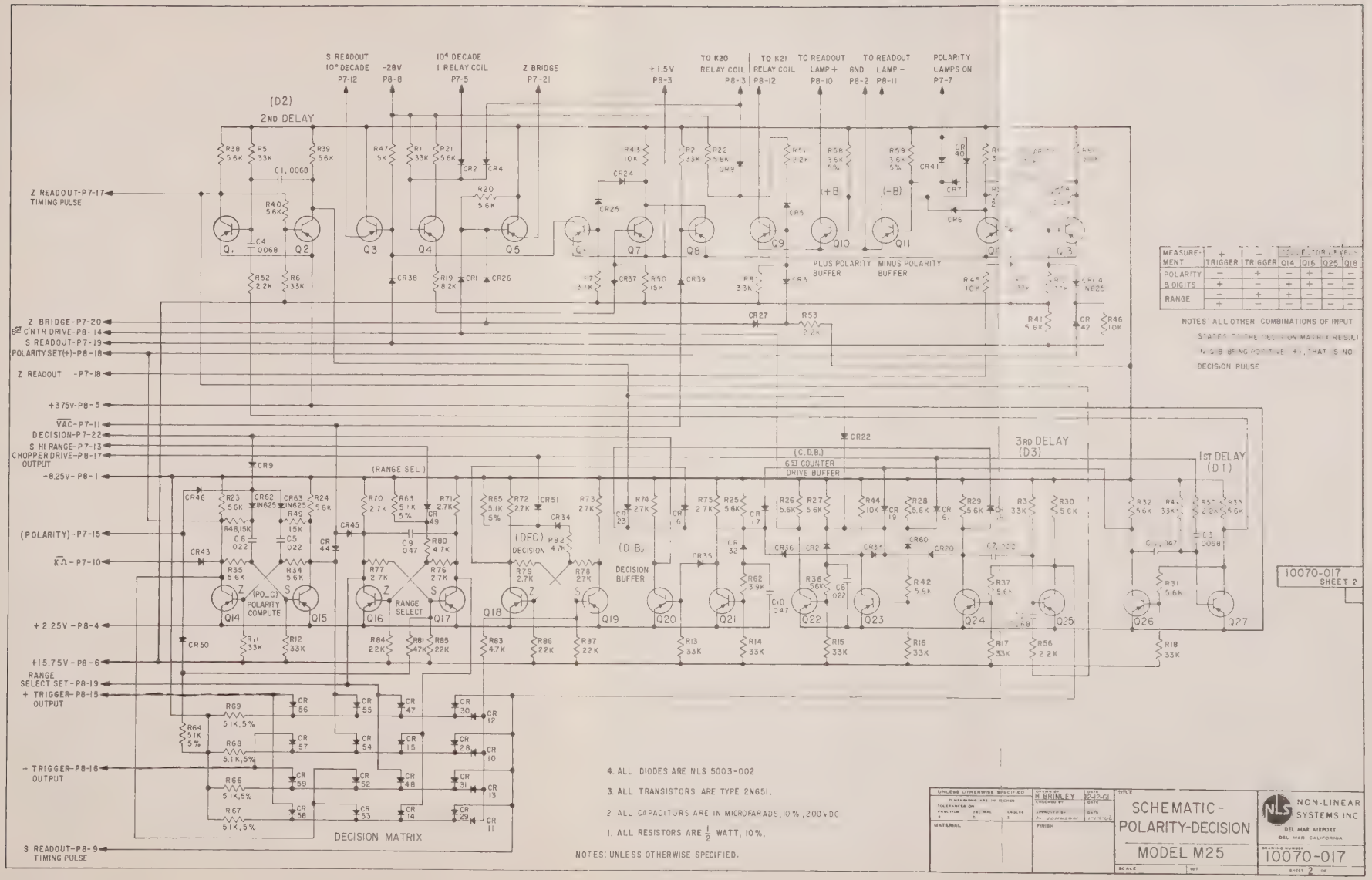
3. ALL DIODES ARE NLS 5003-002

2 ALL TRANSISTORS ARE TYPE 2N651

1. ALL RESISTORS ARE $\frac{1}{2}$ WATT, 10%

NOTES: UNLESS OTHERWISE SPECIFIED

UNLESS OTHERWISE SPECIFIED	DRAWN R. BRADLEY 2-2-66	SCHEMATIC - RANGE - FUNCTION MODEL M25	NON-LINEAR SYSTEMS INC DEL MAR AIRPORT DEL MAR CALIFORNIA
MATERIAL	FINISH	SIZE	DRAWING NO. 10070-015
		SCALE	SHEET 2



MEASUREMENT	+ TRIGGER	− TRIGGER	Q14	Q16	Q25	Q18
POLARITY	−	+	−	+	−	−
& DIGITS	+	−	+	+	−	−
RANGE	−	+	+	−	−	−
	+	−	−	−	−	−

NOTES: ALL OTHER COMBINATIONS OF INPUT STATES TO THE DECISION MATRIX RESULT IN Q18 BEING POSITIVE (+), THAT IS NO DECISION PULSE

10070-017 SHEET 2

4. ALL DIODES ARE NLS 5003-002

3. ALL TRANSISTORS ARE TYPE 2N651.

2. ALL CAPACITORS ARE IN MICROFARADS, 10%, 200 V DC

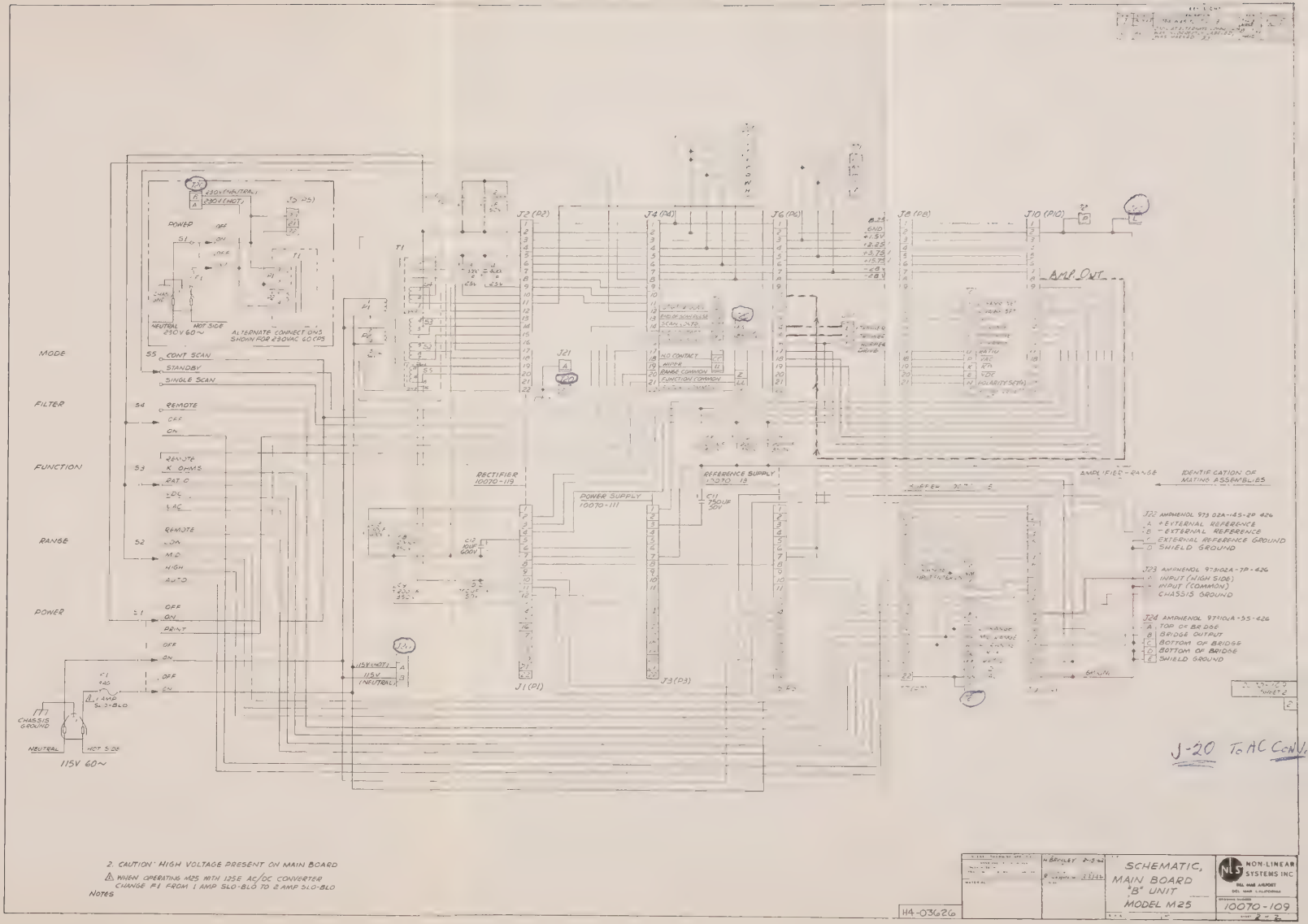
1. ALL RESISTORS ARE ½ WATT, 10%.

NOTES: UNLESS OTHERWISE SPECIFIED.

UNLESS OTHERWISE SPECIFIED	DRAWN H. BRINLEY 12-27-61	TITLE SCHEMATIC - POLARITY-DECISION MODEL M25
MATERIAL	FINISH	SCALE WT

NON-LINEAR SYSTEMS INC
DEL MAR AIRPORT
DEL MAR CALIFORNIA

DRAWING NUMBER 10070-017 SHEET 2 OF

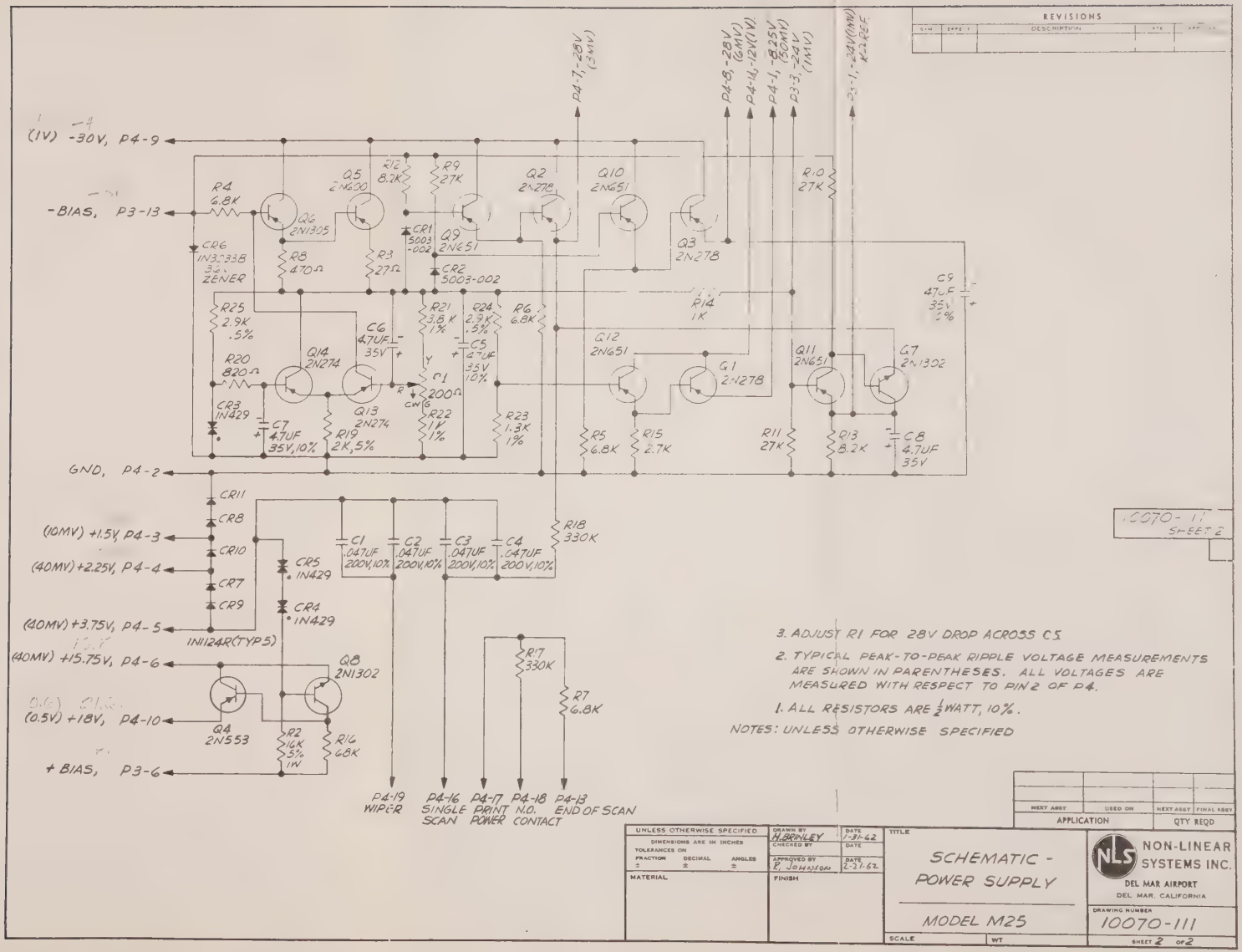


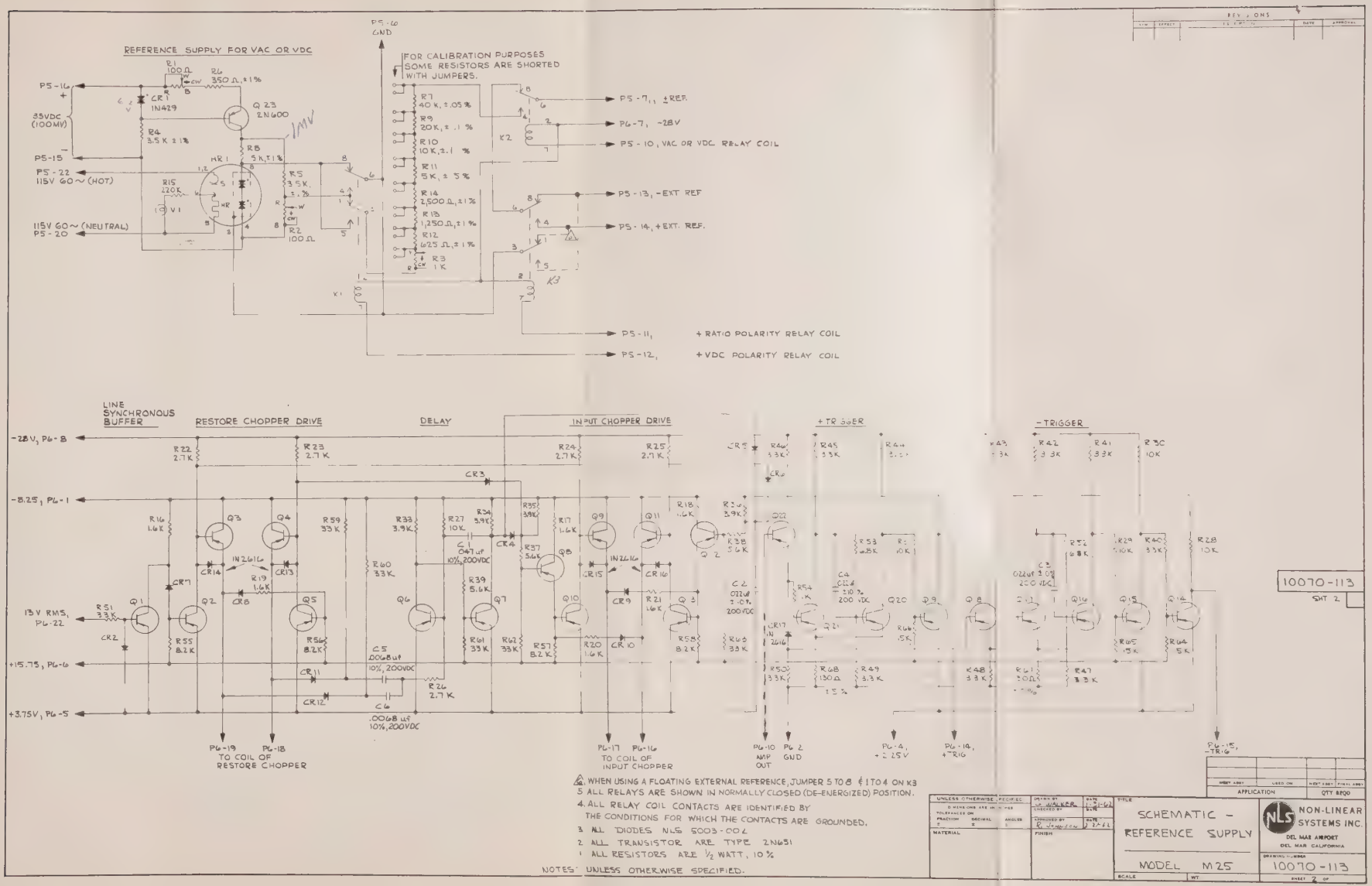
Notes

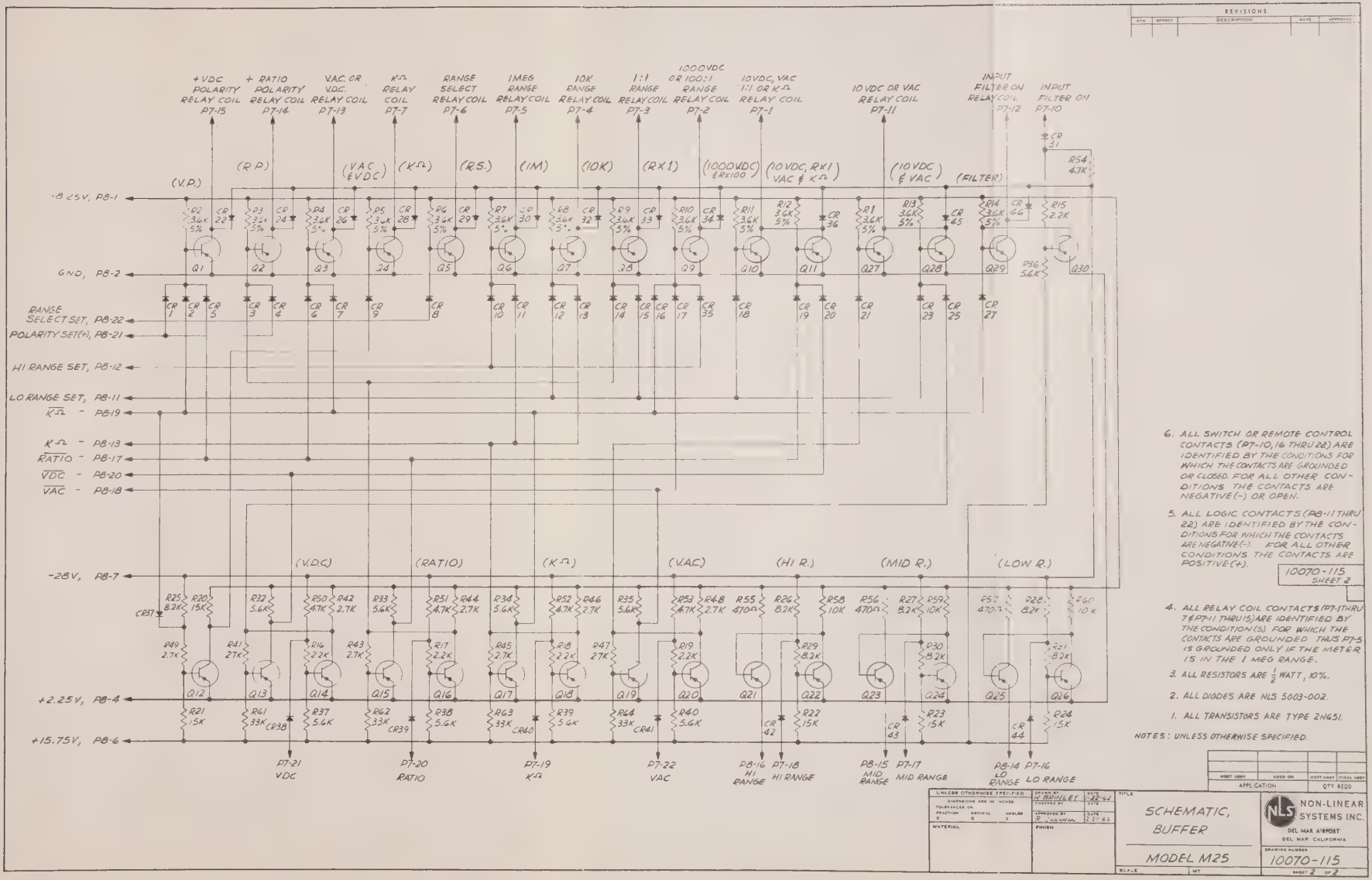
2. CAUTION: HIGH VOLTAGE PRESENT ON MAIN BOARD

⚠ WHEN OPERATING M25 WITH 125E AC/DC CONVERTER CHANGE F1 FROM 1 AMP SLO-BLO TO 2 AMP SLO-BLO

H4-03626		SCHEMATIC, MAIN BOARD "B" UNIT MODEL M25	NON-LINEAR SYSTEMS INC. 10070-109


REVISIONS
SYM
DESCRIPTION
DATE
P4-7, -28V (3MV)
P4-8, -28V (6MV)
P4-14, -12V (1V)
P4-1, -8.25V (50MV)
P3-3, -24V (1MV)
P4-11, -24V (1MV) KEYED
(1V) -30V, P4-9
-BIAS, P3-13
R4 6.8K
Q6 2N1305
Q5 2N600
R12 8.2K
R9 27K
Q9 2N651
Q2 2N278
Q10 2N651
Q3 2N278
R10 27K
CR1 5003-002
CR2 5003-002
CR6 1N3033B 30 ZENER
R8 470Ω
R3 27Ω
R14 1K
C9 47UF 35V 2%
R25 2.9K .5%
R21 3.8K 1%
R24 2.9K .5%
R6 6.8K
C6 47UF 35V
C5 47UF 35V 10%
R20 820Ω
Q14 2N274
Q13 2N274
R1 200Ω CW
R22 1K 1%
R23 1.3K 1%
CR3 1N429
C7 4.7UF 35V, 10%
R19 2K, 5%
Q12 2N651
Q1 2N278
Q11 2N651
Q7 2N1302
R5 6.8K
R15 2.7K
R11 27K
R13 8.2K
C8 4.7UF 35V
GND, P4-2
CR11
CR8
CR10
CR7
CR9
(10MV) +1.5V, P4-3
(40MV) +2.25V, P4-4
(40MV) +3.75V, P4-5
IN1124R(TYP5)
CR5 IN429
CR4 IN429
C1 .047UF 200V, 10%
C2 .047UF 200V, 10%
C3 .047UF 200V, 10%
C4 .047UF 200V, 10%
R18 330K
(40MV) +15.75V, P4-6
Q8 2N1302
R17 330K
R7 6.8K
(0.5V) +18V, P4-10
Q4 2N553
R2 16K 5% 1W
R16 68K
+ BIAS, P3-6
P4-19 WIPER
P4-16 SINGLE SCAN
P4-17 PRINT POWER
P4-18 N.O. CONTACT
P4-13 END OF SCAN
3. ADJUST R1 FOR 28V DROP ACROSS C5
2. TYPICAL PEAK-TO-PEAK RIPPLE VOLTAGE MEASUREMENTS ARE SHOWN IN PARENTHESES. ALL VOLTAGES ARE MEASURED WITH RESPECT TO PIN 2 OF P4.
1. ALL RESISTORS ARE ½ WATT, 10%.
NOTES: UNLESS OTHERWISE SPECIFIED
10070-111 SHEET 2
NEXT ASSY
USED ON
NEXT ASSY
FINAL ASSY
APPLICATION
QTY REQD
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTION DECIMAL ANGLES
± ± ±
MATERIAL
DRAWN BY M. BRADLEY DATE 1-31-62
CHECKED BY DATE
APPROVED BY P. JOHNSON DATE 2-21-62
FINISH
TITLE
SCHEMATIC - POWER SUPPLY
MODEL M25
SCALE WT
NON-LINEAR SYSTEMS INC.
DEL MAR AIRPORT
DEL MAR, CALIFORNIA
DRAWING NUMBER 10070-111
SHEET 2 OF 2


REFERENCE SUPPLY FOR VAC OR VDC
FOR CALIBRATION PURPOSES SOME RESISTORS ARE SHORTED WITH JUMPERS.
PS-16, +35VDC (100MV)
PS-15, −
PS-22, 115V 60~ (HOT)
115V 60~ (NEUTRAL) PS-20
CR1 1N429
Q23 2N600
R1 100Ω
R6 350Ω ±1%
R4 3.5K ±1%
R8 5K, ±1%
R5 3.5K, ±.1%
R15 220K
R2 100Ω
HR1
R7 40K, ±.05%
R9 20K, ±.1%
R10 10K, ±.1%
R11 5K, ±.5%
R14 2,500Ω, ±1%
R13 1,250Ω, ±1%
R12 625Ω, ±1%
R3 1K
K1
K2
K3
PS-7, ±REF.
PG-7, −28V
PS-10, VAC OR VDC RELAY COIL
PS-13, −EXT REF
PS-14, +EXT. REF.
PS-11, +RATIO POLARITY RELAY COIL
PS-12, +VDC POLARITY RELAY COIL
LINE SYNCHRONOUS BUFFER
RESTORE CHOPPER DRIVE
DELAY
INPUT CHOPPER DRIVE
+TRIGGER
−TRIGGER
−28V, PG-8
−8.25, PG-1
13 V RMS, PG-22
+15.75, PG-6
+3.75V, PG-5
PG-19 PG-18 TO COIL OF RESTORE CHOPPER
PG-17 PG-16 TO COIL OF INPUT CHOPPER
PG-10 AMP OUT
PG 2 GND
PG-4, +2.25V
PG-14, +TRIG
PG-15, −TRIG
10070-113
SHT 2
WHEN USING A FLOATING EXTERNAL REFERENCE, JUMPER 5 TO 8 & 1 TO 4 ON K3
5 ALL RELAYS ARE SHOWN IN NORMALLY CLOSED (DE-ENERGIZED) POSITION.
4. ALL RELAY COIL CONTACTS ARE IDENTIFIED BY THE CONDITIONS FOR WHICH THE CONTACTS ARE GROUNDED.
3 ALL DIODES NLS 5003-002
2 ALL TRANSISTOR ARE TYPE 2N651
1 ALL RESISTORS ARE ½ WATT, 10%
NOTES: UNLESS OTHERWISE SPECIFIED.
SCHEMATIC - REFERENCE SUPPLY
MODEL M25
NON-LINEAR SYSTEMS INC.
DEL MAR AIRPORT
DEL MAR CALIFORNIA
10070-113
SHEET 2 OF



6. ALL SWITCH OR REMOTE CONTROL CONTACTS (P7-10,16 THRU 22) ARE IDENTIFIED BY THE CONDITIONS FOR WHICH THE CONTACTS ARE GROUNDED OR CLOSED. FOR ALL OTHER CONDITIONS THE CONTACTS ARE NEGATIVE(-) OR OPEN.

5. ALL LOGIC CONTACTS (P8-11 THRU 22) ARE IDENTIFIED BY THE CONDITIONS FOR WHICH THE CONTACTS ARE NEGATIVE(-) FOR ALL OTHER CONDITIONS THE CONTACTS ARE POSITIVE(+).

10070-115 SHEET 2

4. ALL RELAY COIL CONTACTS (P7-1 THRU 7 & P7-11 THRU 15) ARE IDENTIFIED BY THE CONDITION(S) FOR WHICH THE CONTACTS ARE GROUNDED. THUS P7-5 IS GROUNDED ONLY IF THE METER IS IN THE 1 MEG RANGE.

3. ALL RESISTORS ARE $\frac{1}{2}$ WATT, 10%.

2. ALL DIODES ARE NLS 5003-002.

1. ALL TRANSISTORS ARE TYPE 2N651.

NOTES: UNLESS OTHERWISE SPECIFIED.

REVISIONS				
SYM	EFFECT	DESCRIPTION	DATE	APPROVAL

NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES; TOLERANCES ON FRACTION ± , DECIMAL ± , ANGLES ± ; MATERIAL; FINISH

DRAWN BY H. BWINLEY 1-22-62; CHECKED BY; APPROVED BY R. JOHNSON 2-27-62

TITLE: SCHEMATIC, BUFFER

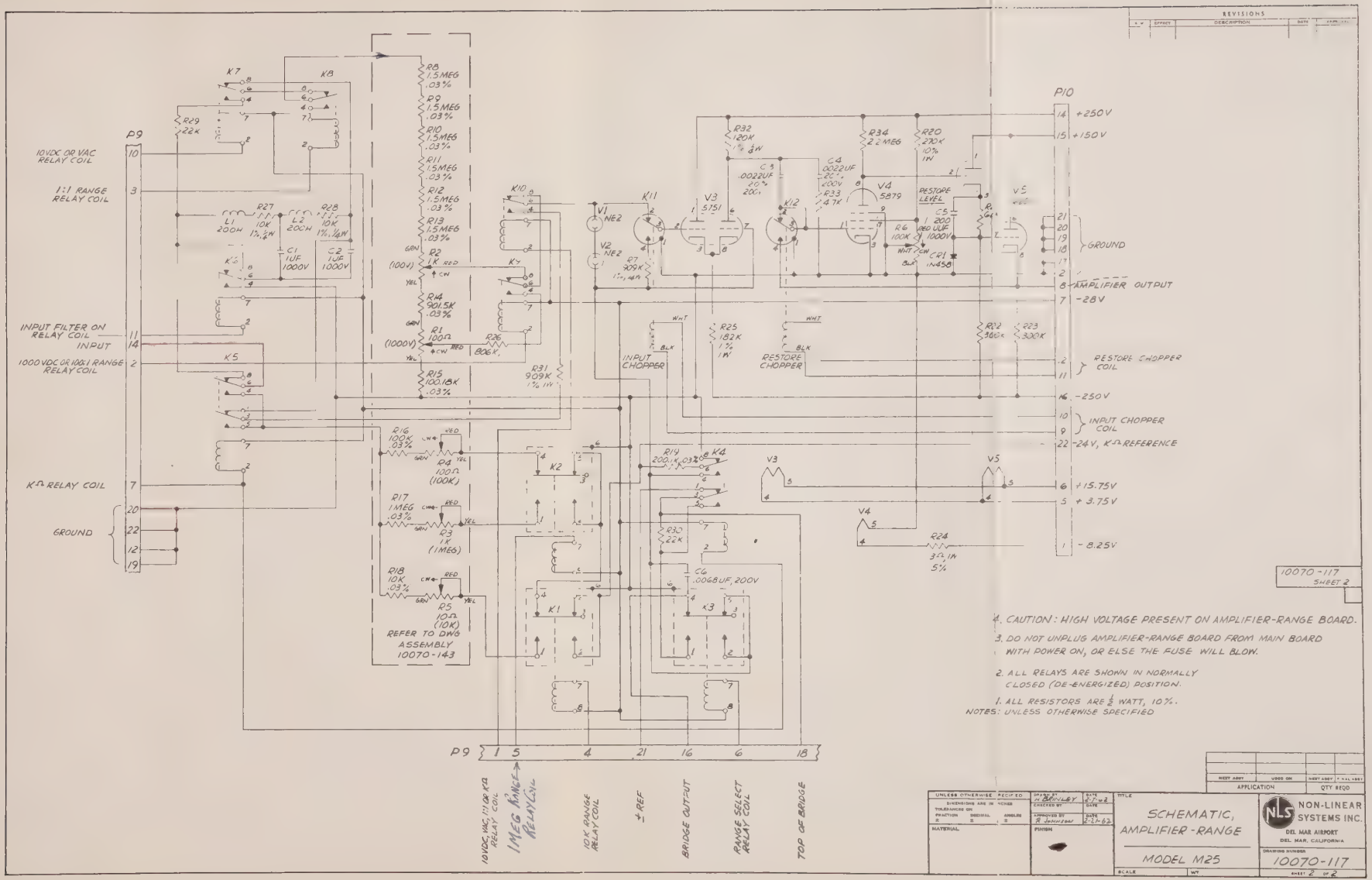
MODEL M25

SCALE; WT

NON-LINEAR SYSTEMS INC.
DEL MAR AIRPORT
DEL MAR CALIFORNIA

DRAWING NUMBER 10070-115

SHEET 2 OF 2



REVISIONS

LTR	EFFECT	DESCRIPTION	DATE	APPR.

10070-117 SHEET 2

4. CAUTION: HIGH VOLTAGE PRESENT ON AMPLIFIER-RANGE BOARD.
3. DO NOT UNPLUG AMPLIFIER-RANGE BOARD FROM MAIN BOARD WITH POWER ON, OR ELSE THE FUSE WILL BLOW.
2. ALL RELAYS ARE SHOWN IN NORMALLY CLOSED (DE-ENERGIZED) POSITION.
1. ALL RESISTORS ARE 1/2 WATT, 10%.

NOTES: UNLESS OTHERWISE SPECIFIED

NEXT ASSY	USED ON	NEXT ASSY	USED ON
APPLICATION		QTY REQD	

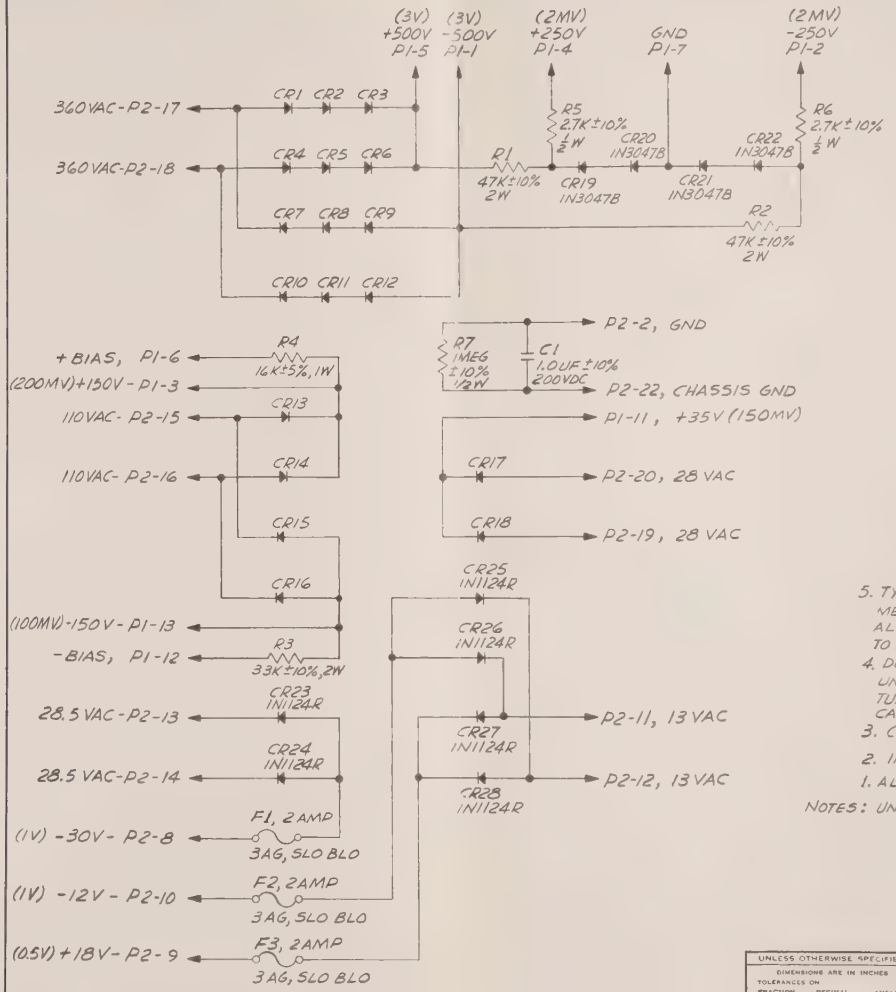
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTION ± DECIMAL ± ANGLES ±
MATERIAL

DRAWN BY J. BRADLEY 5-7-63
CHECKED BY DATE
APPROVED BY R. JOHNSON 5-24-63
FINISH

TITLE: SCHEMATIC, AMPLIFIER-RANGE
MODEL M25
SCALE WT

NLS NON-LINEAR SYSTEMS INC.
DEL MAR AIRPORT
DEL MAR, CALIFORNIA

DRAWING NUMBER 10070-117
SHEET 2 OF 2



NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL DIODES ARE IN2616.
2. IN3047B DIODE IS 130V ZENER.
3. CAUTION: HIGH VOLTAGE PRESENT ON RECTIFIER BOARD.
4. DO NOT UNPLUG RECTIFIER BOARD FROM MAIN BOARD UNTIL AT LEAST TWO MINUTES HAVE ELAPSED AFTER TURNING POWER OFF; THIS ALLOWS THE ELECTROLYTIC CAPACITORS TO DISCHARGE.
5. TYPICAL PEAK-TO-PEAK RIPPLE VOLTAGE MEASUREMENTS ARE SHOWN IN PARENTHESES ALL VOLTAGES ARE MEASURED WITH RESPECT TO PIN 7 OF P1

10070-119 SHEET 2

REVISIONS

SYM	EFFECT	DESCRIPTION	DATE	APPROVAL

NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
APPLICATION		QTY REQD	

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTION ± DECIMAL ± ANGLES ±
MATERIAL

DRAWN BY H. BRINLEY DATE 1-16-62
CHECKED BY DATE
APPROVED BY R JOHNSON DATE 2-21-62
FINISH

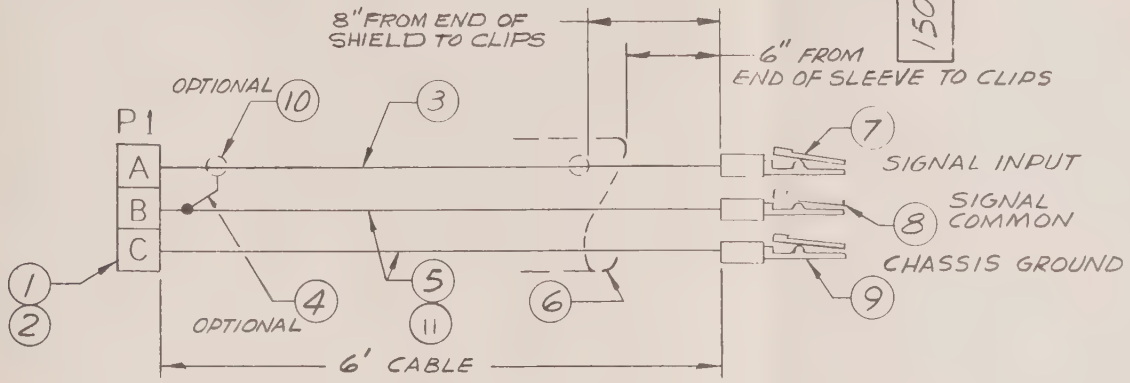
TITLE
SCHEMATIC, RECTIFIER
MODEL M25
SCALE WT

NLS NON-LINEAR SYSTEMS INC.
DEL MAR AIRPORT
DEL MAR, CALIFORNIA
DRAWING NUMBER 10070-119
SHEET 2 OF 2

MANUFACTURERS LIST	
AMP INC.	HARRISBURG, PA.
AMPHENOL	CHICAGO, ILL.
ILLUMITRONIC ENGINEERING CO.	SUNNYVALE, CALIF.
H.H. SMITH INC.	BROOKLYN, N.Y.

15004-075 6

REVISIONS				
SYM	EFFECT.	DESCRIPTION	DATE	APPROVAL
5	M25.1 EM24 10.812	REVISED & REDRAWN FROM "A" SIZE DWG.	10-13-61 H.D.B.	IC R.W.J
6	ALL	ADDED ITEM 11 & NOTE 5 ADDED MFG. LIST	4-24-62 P.W.	R.W.J



ITEM				
5	11	A/R	QQ-S-571B	SOLDER
	10	1	323932	TERMASHIELD AMP
	9	1	300	CLIP (UNINSULATED) H.H. SMITH
	8	1	337	CLIP (BLACK) H.H. SMITH
	7	1	337	CLIP (RED) H.H. SMITH
	6	A/R	V105	SLEEVING, VINYL - 1/4" I.D., ILLUMITRONIC (BLK)
	5	A/R	#20 AWG	WIRE, STRANDED - BLACK
	4	A/R	#22 AWG	WIRE, STRANDED - BLACK (#24 PERMISSIBLE)
	3	A/R	RG122/U	COAXIAL
	2	1	AN3057-6A	CLAMP
	1	1	97310GA-145-75-426	CONNECTOR AMPHENOL

NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
10086	10086	1	1
10070	10070	1	1
10050	10050	1	1
APPLICATION		QTY REQD	

5. SOLDER PER MIL-S-6872.

4. STAMP SYMBOL (P1) ON SLEEVING NEAR CONNECTOR.

3. STAMP PART No. (15004-075) ON SLEEVING.

2. CABLE TO BE TESTED FOR I.R. BETWEEN PINS B & C AND BETWEEN PINS B & C AND SHELLS OF BOTH CONNECTORS. I.R. TO BE 100 MEGOHMS MINIMUM AT 500V.

1. CABLE TO BE TESTED FOR I.R. BETWEEN PINS A & B, A & C ALSO BETWEEN PIN A AND SHELLS OF BOTH CONNECTORS. I.R. TO BE 200,000 MEGOHMS MINIMUM AT 500V.

NOTES:

H4-03626

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTION ±1/2" DECIMAL ± ~ ANGLES ± —

MATERIAL

FINISH

DRAWN BY	H. BRINLEY	DATE 10-13-61
CHECKED BY	K. HALL	DATE 4-20-62
APPROVED BY	R. JOHNSON	DATE 10-17-61

TITLE

CABLE, INPUT

MODEL 20 SERIES

SCALE NONE WT. —

NON-LINEAR SYSTEMS INC.
DEL MAR AIRPORT
DEL MAR, CALIFORNIA

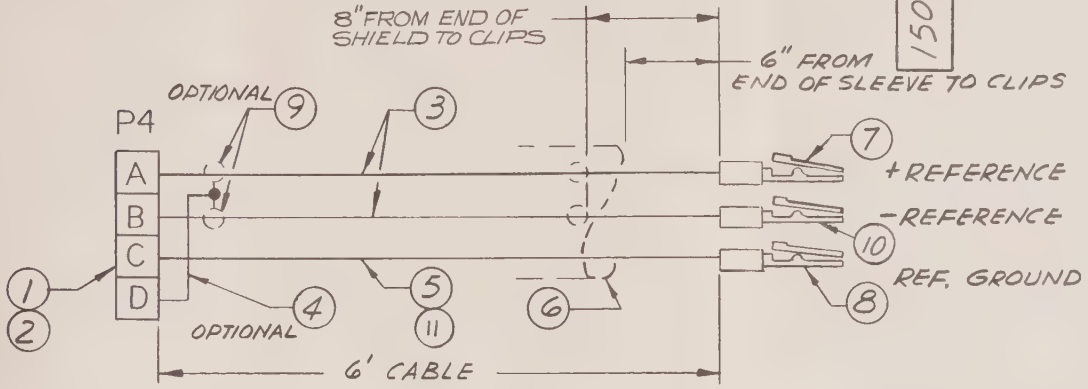
DRAWING NUMBER 15004-075

SHEET 1 OF 1

MANUFACTURERS LIST	
AMP INC.	HARRISBURG, PA.
AMPHENOL	CHICAGO, ILL.
ILLUMITRONIC ENGINEERING CO.	SUNNYVALE, CALIF.
H.H. SMITH INC.	BROOKLYN, N.Y

15004-077 5

REVISIONS				
SYM	EFFECT	DESCRIPTION	DATE	APPROVAL
4	M25.1 & M24 10.812	REVISED & REDRAWN FROM "A" SIZE DWG.	10-13-61 HOB	10-19-61 RWJ
5	ALL	ADDED ITEM 11 & NOTE 4 ADDED MFG. LIST.	4-24-62 R.W.	6B/M



4	11	A/R	QQ-S-571B	SOLDER
	10	1	337	CLIP(RED & BLK) H.H. SMITH
	9	2	323932	TERMASHIELD AMP
	8	1	337	CLIP(BLACK) H.H. SMITH
	7	1	337	CLIP (RED) H.H. SMITH
	6	A/R	V105	SLEEVING, VINYL-5/16" I.D., ILLUMITRONIC(BLK)
	5	A/R	#20 AWG	WIRE, STRANDED - BLACK
	4	A/R	#22 AWG	WIRE, STRANDED - BLACK (#24 PERMISSIBLE)
	3	A/R	RG122/U	COAXIAL
	2	1	AN3057-6A	CLAMP
	1	1	973106A-14S-2S-426	CONNECTOR AMPHENOL

LIST OF MATERIALS

APPLICATION		QTY REQD	
NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
10086	10086	1	1
10070	10070	1	1
10050	10050	1	1

4 SOLDER PER MIL-S-6872.

3. STAMP SYMBOL (P4) ON SLEEVING NEAR CONNECTOR.
2. STAMP PART NUMBER (15004-077) ON SLEEVING.
1. CABLE TO BE TESTED FOR I.R. BETWEEN ALL PINS AND BETWEEN ALL PINS AND SHELLS OF BOTH CONNECTORS. I.R. TO BE 100 MEGOHMS MINIMUM AT 500V.

NOTES:

H4-03626

UNLESS OTHERWISE SPECIFIED	DRAWN BY	DATE
DIMENSIONS ARE IN INCHES	H. BRINLEY	10-13-61
TOLERANCES ON FRACTION ± 1/2" DECIMAL ± ~ ANGLES ± ~	CHECKED BY	DATE
	APPROVED BY R. JOHNSON	DATE 10-17-61
MATERIAL	FINISH	

TITLE

CABLE, EXTERNAL REFERENCE

MODEL 20 SERIES

SCALE | WT. —

NON-LINEAR SYSTEMS INC.
DEL MAR AIRPORT
DEL MAR, CALIFORNIA

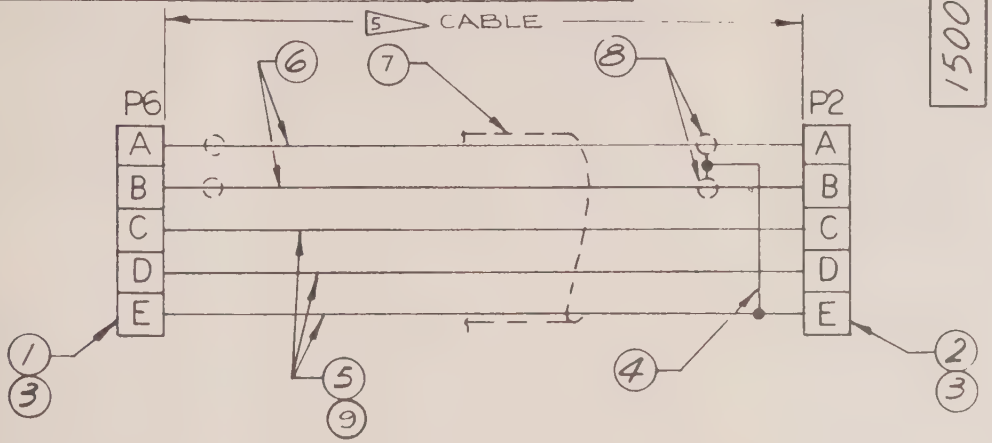
DRAWING NUMBER 15004-077

SHEET 1 OF 1

MANUFACTURERS LIST	
AMPHENOL	CHICAGO, ILL
AMP INC.	HARRISBURG, PA.
ILLUMITRONIC ENGINEERING CO.	SUNNYVALE, CALIF.
BELDEN MFG. CO.	CHICAGO, ILL

15004-078 5

REVISIONS				
SYM	EFFECT	DESCRIPTION	DATE	APPROVAL
4	M25.1/ BM24 10.812	REVISED & REDRAWN FROM "A" SIZE DWG.	10-18-61 MHB	10-19-61 RWJ
5	W.O. 10459	ADDED NOTE 5 CREATING -1	1-9-62 ABW	RGrove 2-2-62



ITEM	REQ'D	PART NUMBER	DESCRIPTION	MATERIAL OR MANUFACTURER	NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
			LIST OF MATERIALS		APPLICATION		QTY REQD	
8	2	323932	TERMASHIELD	AMP	10077	10077	1	1
7	A/R	V105	SLEEVING, VINYL 5/16" I.D., ILLUMITRONIC (BLK)		10086	10086	1	1
6	A/R	RG122/U	WIRE, COAXIAL	BELDEN	10070	10070	1	1
5	A/R	#20 AWG	WIRE, STRANDED - BLK		10050	10050	1	1
4	A/R	#22 AWG	WIRE, STRANDED - BLK (#24 PERMISSIBLE)					
3	2	AN3057-6A	CLAMP, CABLE					
2	1	97310GA-14S-5P-426	CONNECTOR	AMPHENOL				
1	1	97310GA-14S-5S-426	CONNECTOR	AMPHENOL				

5 > 15004-078 AS SHOWN, 6' CABLE; -078-1 IS 9'.

4. STAMP SYMBOLS (P2 & P6) ON SLEEVING NEAR ASSOCIATED CONNECTORS.
3. STAMP PART NUMBER ON SLEEVING.
2. CABLE TO BE TESTED FOR I.R. BETWEEN PINS C & D, C & E, D & E, ALSO BETWEEN PIN C, D & E AND SHELLS OF BOTH CONNECTORS. I.R. TO BE 100 MEGOHMS MIN AT 500V.
1. CABLE TO BE TESTED FOR I.R. BETWEEN PINS A & B, A & C, A & D, A & E, B & C, B & D, B & E; ALSO BETWEEN PINS A & SHELLS OF BOTH CONNECTORS, PIN B & SHELLS OF BOTH CONNECTORS. I.R. TO BE 100,000 MEGOHMS MIN AT 500V.

NOTES:

H4-03626

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTION ± 1/2° DECIMAL ± ANGLES ±

MATERIAL —

DRAWN BY H. BRINLEY DATE 10-18-61
CHECKED BY DATE
APPROVED BY R. JOHNSON 10-19-61

FINISH —

TITLE
CABLE, BRIDGE REFERENCE

SCALE NONE WT. —

NON-LINEAR SYSTEMS INC.
DEL MAR AIRPORT
DEL MAR, CALIFORNIA

DRAWING NUMBER
15004-078

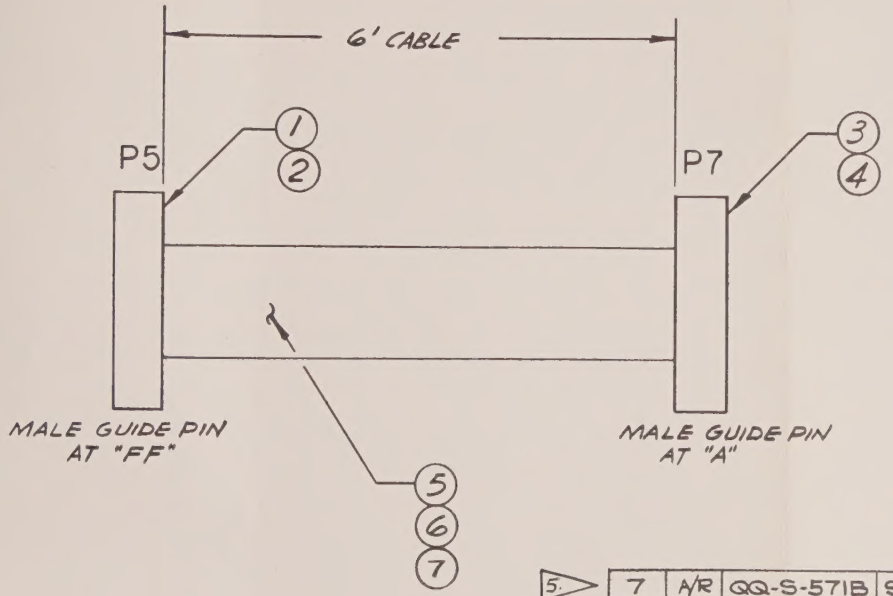
SHEET 1 OF 1

MANUFACTURERS LIST

CONSOLIDATED ELECTRO DYNAMIC CORP. PASADENA, CALIF.
ILLUMITRONIC ENGINEERING CO. SUNNYVALE, CALIF.
MOHAWK ELECTRIC MFG. CO. EAST ORANGE N.J.

15004-079 6

REVISIONS				
SYM.	EFFECT.	DESCRIPTION	DATE	APPROVAL
4	M25.1 & M24 10.812	REVISED & REDRAWN FROM "A" SIZE DWG.	10-17-61 HDB	10-19-61 R W J
5	ELO. 1045900	ADDED NOTE 4 CREATING -1	1-4-62 ARW	R Strouse 2-2-62
6	ALL	ADDED ITEM 7 & NOTE 5	4-24-62 RW	[illegible]



ITEM	REQ'D	PART NUMBER	DESCRIPTION	MATERIAL OR MANUFACTURER	NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
					APPLICATION		QTY REQD	
7	A/R	QQ-S-571B	SOLDER					
6	A/R	V105	SLEEVING, VINYL 5/8" I.D. ILLUMITRONIC (3/4" I.D. PERMISSIBLE)					
5	A/R	8750	CABLE, MOHAWK (22 AWG STRANDED, 50 PCS., ALTERNATE)					
4	50	97502	SOCKETS	C.E.C.	10077	10077	1	1
3	1	2024-005	CONNECTOR	(NON-LINEAR SYS)	10086	10086	1	1
2	50	97503	PINS	C.E.C.	10070	10070	1	1
1	1	2024-004	CONNECTOR	(NON-LINEAR SYS)	10050	10050	1	1

LIST OF MATERIALS

5. SOLDER PER MIL-S-6872.

4. 15004-079 AS SHOWN IS 6' LONG; -079-1 IS 9' LONG.
3. STAMP SYMBOLS (P5 & P7) ON SLEEVING NEAR ASSOCIATED CONNECTOR.
2. STAMP PART NUMBER (15004-079) ON SLEEVING. (USE APPLICABLE DASH NO.)
1. CONTACTS TO BE WIRED A TO A, B TO B, C TO C, ... ETC.

NOTES:

H4-03626

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTION ± 1/2 DECIMAL ± ~ ANGLES ±

MATERIAL

FINISH

DRAWN BY H. BRINLEY DATE 10-17-61
CHECKED BY [illegible] DATE 10-18-61
APPROVED BY R. JOHNSON DATE 10-19-61

TITLE

CABLE
POWER & LOGIC

MODEL M24

SCALE NONE WT.

NON-LINEAR SYSTEMS INC.
DEL MAR AIRPORT
DEL MAR, CALIFORNIA

DRAWING NUMBER
15004-079

SHEET 1 OF 1

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DEL MAR, CALIFORNIA

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